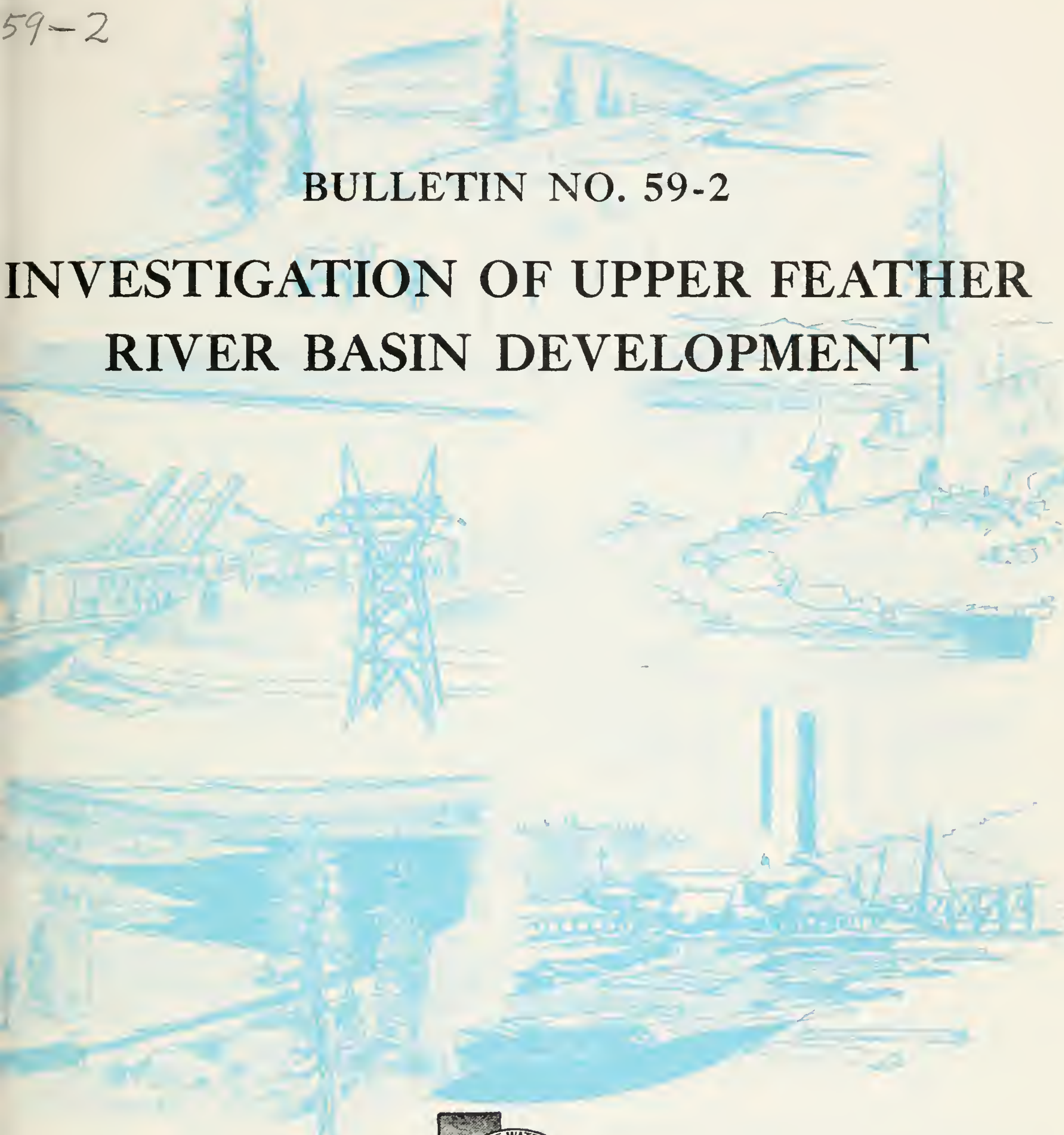
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

BULLETIN NO. 59-2

INVESTIGATION OF UPPER FEATHER RIVER BASIN DEVELOPMENT



EDMUND G. BROWN
Governor

HARVEY O. BANKS
Director of Water Resources

OCTOBER 1960

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DEPARTMENT OF WATER RESOURCES
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North Fork of the Feather River Near Belden

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HARVEY O. BANKS
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STATE OF CALIFORNIA
Department of Water Resources
SACRAMENTO

October 28, 1960

Honorable Edmund G. Brown, Governor, and
Members of the Legislature of the
State of California

Gentlemen:

There is transmitted herewith Bulletin No. 59-2 of the Department of Water Resources, entitled "Investigation of the Upper Feather River Basin Development". This bulletin is a report of the investigation conducted as authorized by the Legislature in Item 223.1 of the Budget Act of 1956.

Bulletin No. 59-2 presents a basin-wide master plan for multipurpose water development for all beneficial uses. This plan would serve to guide and coordinate the planning, construction, and operation of works required for the development and utilization of the water resources of the Upper Feather River Basin.

Very truly yours,

Harvey O. Banks

HARVEY O. BANKS
Director

Enc.

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ACKNOWLEDGMENT

Valuable assistance and data used in this investigation were contributed by agencies of the State and Federal Governments, Plumas County, public districts, and private companies and individuals. This cooperation is gratefully acknowledged.

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California Department of Fish and Game
California Division of Beaches and Parks
Plumas County Water Resources Board
Plumas County Board of Supervisors
Plumas County Chamber of Commerce
Last Chance Creek Water District
Agriculture Commissioner and the Farm Advisor of Plumas and Sierra Counties

CHAPTER I. INTRODUCTION

The rapid expansion of population in California since World War II has resulted in increased interest in present and future water requirements and in the need for water supply development. This is particularly evident in the southern and central portions of the State where the expansion of agriculture and industry is depleting local water supplies and has created an interest in the possibilities of obtaining supplemental water from northern regions of surplus.

Realizing that the water resources of the State must be developed to meet increasing water needs, the Legislature has provided funds for the planning of a coordinated statewide development of the water resources of the State. Also, as a part of authorizing legislation for the Central Valley Project, the Legislature established the policy that water in sufficient quantity to meet the future needs of a watershed or area wherein water originates must be reserved for use in such areas. The spirit and intent of this policy has governed all state planning for water resource development since 1933. This policy applies specifically to the Feather River and Delta Diversion Projects under construction by the State as the authorizing legislation made all provisions of the Water Code relating to the Central Valley Project applicable to the state project.

However, with the initiation of planning for the conservation of the surplus waters of the north for conveyance southward to areas of need, the people of the northern part of the State have shown mounting concern over the disposition of local water supplies. Local water demands in areas of origin are rising, and there is concern that continued appropriation of water for use in outside areas may jeopardize future water supplies to meet local requirements. There has been an insistence, therefore, that the development of projects to supply the needs of the areas of origin be advanced at the same time as projects are developed to export water to outside areas.

To evaluate the water requirements of the northern part of the State, the Legislature, in 1954, appropriated funds for the Northeastern Counties Investigation. An interim report on this investigation, entitled "Report on the Upper Feather River Service Area", was issued in April 1955, by the (then) Division of Water Resources. This report presented data on present and probable ultimate water requirements and set forth a preliminary plan for the development of the water resources of the Upper Feather River Basin. Following the publication of the report and subsequent public hearings, the Legislature directed that the Department of Water Resources complete its investigation of the feasibility of constructing water conservation projects in the Upper Feather River Basin. In February 1957, the Department of Water Resources published Bulletin No. 59, entitled "Investigation of Upper Feather River Basin Development, Interim Report on Engineering, Economic, and Financial Feasibility of Initial Units". Bulletin No. 59 contains results of studies showing that the Frenchman Project, the Grizzly Valley Project, and the Indian Creek Recreation Project are engineerly feasible and economically justified. Following the publication of Bulletin No. 59 and authorization of these projects by the Legislature, studies of the development of the water resources of the Upper Feather River Basin were continued to completion. The results of these studies, together with the results contained in the 1955 report and Bulletin No. 59, are reported herein.

Authorization for Investigation

In the Budget Act of 1956, Item 223.1, the Legislature provided:

"For completion of engineering and geologic investigations, studies, and report with recommendations for a construction program for multipurpose water development and flood control projects in the Upper Feather River Service Area."

Additional funds for the investigations were provided under Item 263 of the Budget Act of 1957.

Objective and Scope of the Investigation

The objective of this investigation was to develop a basin-wide master plan for multipurpose water development for all beneficial uses in the Upper Feather River Basin. Beneficial uses of water given consideration included irrigation, domestic, recreation, fish and wildlife, and the production of hydroelectric energy.

Each of the projects considered for development was analyzed separately to determine its engineering feasibility and economic justification. The economically justified projects found feasible for construction in the immediate future were subjected to a more detailed analysis than those projects planned for ultimate development.

Six alternative plans were considered for developing the hydroelectric power and water conservation potential of the Middle Fork Feather River. These alternative plans were developed to a degree sufficient to compare their respective project accomplishments.

Data presented in the interim report on the Northeastern Counties Investigation were reviewed and utilized in evaluating the plan for the Upper Feather River Basin development. Additional hydrologic studies were made to refine previous estimates of the amount of firm seasonal water yield and hydroelectric energy that could be realized from the Upper Feather River Basin development.

Geologic exploration programs were conducted to determine dam site foundation conditions and the suitability of material for use in construction of dams. The exploration programs included foundation drilling of 15 dam sites. However, exploration of the dam sites proposed by the Richvale Irrigation District in the canyon of the Middle Fork of the Feather River were limited to geologic reconnaissance studies. In addition to the drilling operations, the geologic investigation included location of borrow areas for material and sampling of these materials for construction purposes.

For each project considered, engineering designs and estimates of cost were prepared for several capacities of reservoir storage. Economic studies were made to determine irrigation, power, and flood control benefits that would be attributable to projects regulating the waters of the Upper Feather River Basin. Pacific Planning and Research, a consulting economic and recreational planning firm, was retained by contractual agreement to determine the recreational benefits that would result from the projects A report on the results of these studies is included as Appendix A to this bulletin and is entitled "Recreation Benefits from the Upper Feather River Basin Development".

During 1958, the Oroville-Wyandotte Irrigation District and the Yuba County Water Agency, in cooperation with the Pacific Gas and Electric Company, entered into an agreement on a plan for the development of the waters of the South Fork of the Feather River. Since the Federal Power Commission has issued a license and the State Water Rights Board has issued water rights permit for this development, no plans were evolved by the department for developing the South Fork of the Feather River. A brief description of the Oroville-Wyandotte-Yuba County Water Agency plan is presented in Chapter VI.

Results of the Upper Feather River Basin Investigation are presented in the six ensuing chapters. In Chapter II, there are presented

Drilling Borrow Site

the criteria, methods of analysis, and basic procedures used in planning and evaluating the possibilities for water resource development. Legal considerations pertaining to water development are presented in Chapter III. Chapter IV contains discussions of precipitation, surface water, ground water, and water quality. In Chapter V estimates of present and future land use patterns, and water requirements are presented. A basin-wide plan of water development, including alternative development possibilities, is presented in Chapter VI. A summary of the findings of the investigation, conclusions, and recommendations based thereon are presented in Chapter VII.

Related Investigations and Reports

Several prior investigations and reports of the Department of Water Resources, and its predecessor agency, the Division of Water Resources, were reviewed in connection with this investigation. A brief summary of these investigations is presented in the following discussion.

State-Wide Water Resources Investigation

The California Legislature, in recognition of the growing statewide water problem, directed the State Water Resources Board, by Chapter 1541, Statutes of 1947, to conduct an investigation of the water resources of California. This study was designated the "State-Wide Water Resources Investigation". Funds were provided in the 1947-48 budget for commencement of the investigation and additional funds were provided in the budget acts of subsequent years for the completion of the investigation.

The State-Wide Water Resources Investigation was conducted under direction of the State Water Resources Board by the Division of Water Resources of the Department of Public Works. Three bulletins were published containing the results of this investigation. Bulletin No. 1, "Water Resources of California", published in 1951, contains a compilation of data on precipitation, unimpaired stream runoff, flood flows and frequencies, and quality of water throughout the State. Bulletin No. 2, "Water Utilization and Requirements of California", published in June 1955, includes estimates of the present use of water throughout the State for all consumptive purposes and presents forecasts of probable ultimate water requirements based, in general, on the capabilities of the land to support further development. The third, and concluding, phase of the State-Wide Water Resources Investigation was reported in Department of Water Resources Bulletin No. 3, "The California Water Plan". This bulletin, published in May 1957, presents a comprehensive master plan for the full practicable development of the water resources of the State to meet future needs for all beneficial purposes to the maximum feasible extent. The Legislature in 1959 adopted the California Water Plan as a general guide for the orderly and coordinated development and utilization of the water resources of the State.

Northeastern Counties Investigation

The Northeastern Counties Investigation, a detailed study of land and water uses and requirements in the 15 northeastern counties of the State, was initiated in 1954. In April 1955, an interim report on the Upper Feather River Basin portion of this investigation was published. This interim report is entitled, "Report on the Upper Feather River Service Area", A preliminary report covering the entire investigational area, Bulletin No. 58, "Northeastern Counties Investigation", was published in December 1957. Data presented in these publications were utilized in the Upper Feather River Basin Investigation.

Area Under Investigation

The Upper Feather River Basin includes lands within the watershed boundary of the Feather River above the authorized Oroville Dam located on the Feather River near Oroville. It has an area of approximately 2,261,000 acres of which about 1,643,000 acres are in Plumas County. The remaining area is divided among three counties as follows: Butte County, 332,000 acres; Sierra County, 167,000 acres; and Lassen County, 119,000 acres. County boundaries and those of the basin are delineated on Plate 1, "Location of Upper Feather River Basin".

During the course of studies for the Northeastern Counties Investigation, the Upper Feather River Basin was divided into five principal hydrographic units. The boundaries of these units were defined after giving consideration to factors of water supply, water utilization, and topography. These same hydrographic units were used in the Upper Feather River Basin Investigation and are delineated on Plate 5, "Present and Probable Ultimate Land Use".

Drainage Basins

The Feather River drains the western slope of the Sierra Nevada by three main tributaries that join just a few miles above the point where the river enters the Sacramento Valley. Of these major tributaries, the North Fork is the largest, draining 2,090 square miles, or 59 percent of the total area. The Middle and South Forks of the Feather River drain the remainder of the mountainous area from the crest of the Sierra Nevada westward to their confluence near Bidwell Bar.

The portion of the Sierra Nevada located in the Feather River Basin has a long gentle slope southwestward to the floor of the Sacramento Valley, and a short steep slope northeastward to Honey Lake Valley. The northern portion of the Sierra Nevada splits into three parallel crests, each with a valley or valleys to its northeast. American Valley at Quincy and Mohawk

Valley at Blairsden lie to the northeast of the Clermont Hills, Indian Valley to the northeast of Grizzly Mountains, and Honey Lake Basin to the northeast of Diamond Mountains. Elevations above sea level range from 6,000 to 8,500 feet along the crests of the mountains and from 4,000 to 5,500 feet on the valley floors. The effect of this configuration in the natural drainage is to create streams of moderate gradient in the upper portion of the basin, some of which flow in a northwesterly direction, while some flow in a southeasterly direction. The grade increases as the tributaries flow into the main water courses which have cut deep and rugged canyons in a southwesterly direction down the slope of the Sierra Nevada.

Natural Features

Extensive areas of merchantable timber land, extremely rough and rocky terrain cut by precipitous canyons, and isolated mountain valleys in which grain and meadow hay are grown, characterize the Upper Feather River Basin. At lower elevations, dense oak groves are the dominant vegetative cover, but at elevations from about 1,500 to 2,000 feet the oaks merge with the coniferous forests that extend throughout the remainder of the basin. Ponderosa pine, Douglas fir, and white fir are the most abundant species. Forests of pine, fir, and cedar are broken by bare granitic peaks, deep and rugged canyons, and irrigable valleys. Auriferous gravels occur throughout portions of the basin.

A prominent feature of the eastern portion of the Upper Feather River Basin is Sierra Valley. This flat valley, an old lake bed with an area of approximately 155 square miles lying at an elevation of about 5,000 feet, is enclosed by mountains except for its drainage outlet, the Middle Fork of the Feather River. The valley is used extensively for raising meadow hay and as summer livestock range.

Mt. Lassen and the surrounding volcanic terrain dominate the northern part of the Upper Feather River Basin. Runoff from this area is regulated by Lake Almanor, from which releases are made to operate the hydroelectric power development of the Pacific Gas and Electric Company on the North Fork of the Feather River.

Climate

The western slope of the northern Sierra Nevada is a region of large climatic differences. Marked differences in temperature and precipitation occur within short distances where air movement is substantially affected by the topography.

The mean seasonal depth of precipitation in the Upper Feather River Basin increases with elevation from about 27 inches at Oroville to over 80 inches in the vicinity of the Butte-Plumas County line, and decreases to about 20 inches on the crest of the Diamond Mountains and to less than 10 inches in part of Sierra Valley. Most of the precipitation at higher elevations occurs as snowfall and is retained in a heavy pack until the spring and summer snowmelt runoff period. Temperatures in the mountain valleys are moderately severe, with minimums below freezing during the period from November through March. The summers are generally warm during the day, but cool during the night. Frosts may occur in any month of the year.

A summary of pertinent climatological data for eight selected stations in or adjacent to the Upper Feather River Basin is presented in Table 1.

TABLE 1

CLIMATOLOGICAL DATA FROM SELECTED STATIONS
IN OR ADJACENT TO THE UPPER FEATHER RIVER BASIN

Station	Elevation, in feet	Maximum and minimum temperatures for period of record, in degrees Fehrenheit		Mean seasonal depth of precipitation, in inches
		Maximum	Minimum	
Westwood	5,065	96	-21	25.25
Sierraville	4,975	99	-23	24.22
Portola	4,834	100	-21	18.14
Canyon Dam	4,555	102	-14	36.77
Greenville	3,560	105	-14	35.75
Quincy	3,409	105	-19	39.05
De Sabla	2,713	104	12	60.98
Oroville	160	115	18	27.07

Soils

Soils in the Upper Feather River Basin vary markedly in composition, depth, and other physical and chemical properties. These variations result from differences in parent material, mode of formation, degree of development, and climatic factors. In general, the soils can be divided into the following five broad groups:

1. Residual soils which have been formed in place by disintegration and weathering of underlying consolidated sedimentary and igneous rocks.

2. Old valley-filling soils which have undergone marked changes in profile characteristics since their deposition.

3. Recent alluvial soils which occupy the flood plains and upland meadow valleys, and have been derived from sediments transported from the

immediate surrounding area. There has been little change in the physical and chemical properties of these soils since their deposition.

4. Lacustrine soils, some of which have undergone pronounced changes in profile characteristics since their deposition.

5. Organic soils which have been derived mainly from decomposition of organic materials under marshy conditions.

The residual soils occur on hilly and mountainous lands throughout the area. These soils have been formed in place through the action of weathering upon the underlying material and vary in profile characteristics, according to the effect of differences in climatic factors and parent materials. Depths of soil vary from very shallow soils with considerable rock present on the surface and throughout the profile, to very deep soils with little or no rock evident. The limitations associated with the utilization of most residual soils result from a combination of complex topographic conditions, shallow soil depths, and excessive amounts of surface rock. However, under certain conditions, these soils are capable of sustaining climatically adapted crops.

Soils derived from old valley deposits and remnants of former alluvial fans, although not extensive in the upper basin, are found along the western side adjacent to the Sacramento Valley floor. Soil-forming processes have brought changes in profile characteristics during the period following deposition of the unconsolidated materials. Leaching processes have resulted in formations of dense clay pans and, in some cases, cemented hardpans. These terrace soils are generally suitable only for shallow-rooted crops.

Recent alluvial soils occupy the flood plains and smaller meadows along streams and occupy the greater part of the larger mountain meadows such as American Valley and Indian Valley. These soils, in general, have undergone little or no change in their profile characteristics since deposition. Where properly drained, the recent alluvial soils have wide crop adaptabilities and are highly valued as agricultural lands.

Soils derived from lacustrine depositions occupy the greater part of Sierra Valley. As is common with the deposition of sediments into a fresh-water lake, coarser materials are found at the margins of the valley and the finer materials are found in the central portions of the valley. Thus, a wide textural range has been developed with a predominance of fine- or medium-textured soils. This soil condition creates drainage problems which are responsible in large part for much of the salinity and alkalinity conditions that are found in Sierra Valley. Many of these drainage problems could be alleviated by artificial drainage. In general, all of these lands are suitable for medium- and shallow-rooted, climatically adapted crops.

Within Indian Valley there are small areas of soils that have been derived largely from the deposition of organic materials. In general, these organic soils have proven highly productive where reclamation has been brought about through drainage. They are normally deep, medium-to-fine textured, and suited to a wide variety of climatically-adapted crops.

Geology

The Upper Feather River Basin is bounded on the northwest and north by volcanic ridges and mountains, including Mount Lassen, which are a part of the Cascade Range geomorphic province. On the northeast and east, the basin is bounded by prominent, east-facing fault scarps located near Honey Lake and along the east margin of the Sierra Nevada. The northern and eastern boundaries of the basin roughly correspond to the northern and eastern boundaries of the Sierra Nevada geomorphic province. On the south, the boundary of the Upper Feather River Basin follows a series of ridges which are part of the western slope of the Sierra Nevada. Runoff from the entire drainage area of the Feather River is funneled through a single narrow channel at the Oroville dam site. The general course of the main forks of the Feather River and its chief tributaries is southwest. However, some marked exceptions to the southwest drainage pattern occur where the structural features of the region have influenced the course of the tributary streams.

The Sierra Nevada is a complex mountain range composed of metamorphic and igneous rocks. Faulting, tilting and uplift of the Sierra Nevada formed the extremely steep, eastern escarpment and resulted in the carving of deep canyons by youthful streams on the otherwise gentle western slope. In the Upper Feather River Basin the Sierra Nevada has been modified by additional faulting which has produced several prominent scarps and has influenced the formation of all major valleys in the basin.

The older rocks in the area are metamorphic. These rocks range in age from Silurian (about 350 million years old) to Jurassic (about 150 million years old). Argillite, slate, mica schist, graywacke, quartzite, and occasionally limestone were derived from sedimentary rocks, and greenstone, amphibolite, talc schist, and chlorite schist were derived from volcanic rocks. The bedding and schistosity of the metamorphic rocks are very steeply inclined. The major structures and lineation trend northwest, parallel to the crest of the Sierra Nevada. Masses and dikes of various granular igneous rocks, such as granite and gabbro, irregularly intrude the older rocks. Metamorphism of the older rocks is attributed to this intrusion.

Serpentine, which is a moderately soft, predominantly green alteration product of ultra-basic intrusive igneous rocks, is prominent in the area. An almost continuous broad band of serpentine crosses the entire drainage area from southeast to northwest. The band crosses the Middle Fork of the

Feather River four miles below Nelson Point, passes through Meadow Valley, and crosses U. S. Highway 40 (Alternate), the east Branch of the North Fork in Serpentine Canyon, and the North Fork of the Feather River about three miles above Belden. The band is about three miles wide where it crosses the Middle and North Forks of the Feather River.

Younger deposits in the Upper Feather River Basin include auriferous gravels, volcanic rocks, lake sediments, and alluvium. Areas of gravels, some richly auriferous, are found on the crests of several interfluvial ridges. The gravels were deposited from Eocene to Miocene time (between about 70 million and 20 million years ago). Such isolated gravel deposits provide evidence of the difference between the ancient prevolcanic stream drainage pattern and the drainage pattern of the Feather River today.

Many of the auriferous gravel deposits were buried by volcanic rocks (lava flows, tuffs, beds of volcanic boulders and ash), which at one time probably blanketed the entire eastern two-thirds or more of the area. In the eastern part of the area around Sierra Valley much of the thick volcanic cover remains today. In addition, erosional remnants of the great mass of pyroclastic debris still remain on many of the high ridges in the central part of the basin. These lava flows and beds of pyroclastic debris were laid down during late Miocene and early Pliocene time (about 10 to 15 million years ago).

Structural dislocations and depressions in small parts of the Sierran block resulted in the formation of several valleys in the Upper Feather River Basin. Since the formation of the valleys, sediments have accumulated almost continuously. Lake sediments and stream deposits are predominant in most valleys; volcanic ash is abundant in some valleys; and glacial debris and wind-blown material have been noted in other valleys.

The larger of these complex alluviated valleys are: Sierra Valley, Mohawk Valley, Big Meadows Valley (now inundated by Lake Almanor), Mountain Meadows Valley (partially inundated by Mountain Meadows Reservoir), Indian Valley, American Valley, Meadow Valley, Grizzly Valley, and Genesee Valley. Smaller alluviated areas are found also in such well-defined valleys as Squaw Valley, Clover Valley, and Little Last Chance Valley.

The youngest sediments in the Upper Feather River Basin are the Recent stream channel deposits. These consist of boulders, gravel, sand, and silt. Channel and terrace gravels have yielded gold at many localities.

No appreciable movement along major faults has been recorded within the Upper Feather River Basin. However, faults in adjacent areas are considered active. Therefore, for purposes of design, the area was considered to be moderately active seismically.

Regional geology is presented on Plate 2, "Regional Geology of the Upper Feather River Basin".

Past and Present Development

While gold was the original lure that brought immigrants into the Upper Feather River Basin, it was the vast timber stands, mountain meadows, hydroelectric power potentiality, and the location of a transcontinental railroad that were responsible for the present pattern of development. Gold was discovered at Bidwell Bar at the confluence of the Middle and South Forks of Feather River shortly after Marshall's strike at Coloma in 1848, and within a few years numerous gold camps were scattered along the streams of the basin. For many years this industry held an important place in the economy of the region. However, in recent years economic conditions have forced mining into the background. Placer and hydraulic methods were utilized in the mining operations. Water for these operations was diverted and conveyed in flumes and canals, many of which now convey water for irrigated agriculture and hydroelectric power generation.

Most of the development of hydroelectric power in the Upper Feather River Basin has occurred during two distinct periods. The first development occurred during the early 1900's, and the second occurred during the years following World War II. Investigations and studies that led to formation of the Great Western Power Company began in 1901 when Julius M. Howells, a civil engineer, became interested in hydroelectric development possibilities on the North Fork of the Feather River. He had noticed the exceptional storage possibilities at Big Meadows, now Lake Almanor, and the rapid fall of the Feather River below that point. His investigations initiated a series of negotiations for property and financial backing that culminated in the construction of Big Meadows Dam, the Big Bend and Caribou hydroelectric power plants, transmission lines to the San Francisco Bay area, and a number of auxiliary steam electric power plants. By 1924, approximately 131,000 kilowatts of hydroelectric power capacity had been installed on the North Fork. The system on the North Fork of the Feather River is now owned and operated by the Pacific Gas and Electric Company. It consists of power plants with a total installed power capacity of 635,800 kilowatts. In addition to the Big Bend and Caribou power developments, the system consists of the Cresta, Rock Creek, Bucks Creek, Poe, and Hamilton Branch hydroelectric power plants, and four major reservoirs--Lake Almanor, Mountain Meadows, Butt Valley, and Bucks--which provide regulatory storage for operation of the hydroelectric power plants.

Early settlers of the mountainous regions of the Upper Feather River Basin were attracted by favorable conditions for livestock raising.

Grasses grow abundantly during the spring months, and streams are easily diverted onto the flat valley floors to irrigate hay and summer pastures. The livestock activity grew rapidly to become, and has remained, one of the predominant industries of the basin. Present agricultural development in the mountain valleys is still limited by the vagaries of natural stream flow. The ease of diversion of stream flow, and the small financial investments required, permitted irrigation development by individuals or small groups of individuals. This method of direct diversion of stream flow has prevailed to the present time.

As the numbers of farmers increased and as the use of water intensified, questions arose among the diverters concerning rights to the use of water. Finally, a petition requesting determination of the rights of various claimants to waters of the Middle Fork of the Feather River above Beckwourth was filed in 1936 with the then Division of Water Resources. A petition for determination of rights to the waters of Indian Creek was similarly filed in 1944. Following each petition, the division conducted investigations leading to determinations of all rights, which were thereafter established by court decrees. Watermasters presently distribute the water of these streams and their tributaries to the water users in accordance with the decrees.

Present irrigation development in foothill areas of the Upper Feather River Basin has in most instances evolved from privately developed water systems constructed for mining purposes. With the decline of mining, the systems were gradually converted into irrigation projects, and by reorganization and purchase, the private holdings were combined and turned into convenient forms of public districts. The Oroville-Wyandotte Irrigation District, holding water rights to flows of the South Fork of the Feather River and its tributary, Lost Creek, presently provides a water supply for about 4,500 acres of irrigable land located in the foothills of the Sierra Nevada in Butte County.

Transportation facilities in the Upper Feather River Basin include the major transcontinental line of the Western Pacific and spur lines of the Southern Pacific Railroads, United States Highway 40 (Alternate), State Highway Routes 36, 49 and 89, and many miles of county roads. Even though these facilities provide year-round access to the major communities and agricultural areas of the basin, there are many parts that can be reached only during the summer months.

The timber resources of the Upper Feather River Basin exceed 21 billion board feet, approximately 70 percent of which is in public ownership. Timber cropland covers about 55 percent of the land area, a large part of which is available for commercial purposes.

The timbered mountains and the lakes and streams of the primitive portions of the Upper Feather River Basin offer the more venturesome vacationists unusual recreational opportunities such as remain available in only a few parts of the Sierra Nevada. Those large portions of the basin which are accessible by road or railroad provide year-round tourist accommodations with outdoor sports of swimming, boating, hunting, and fishing in the summer, and skiing in the winter. Recreation and travel by vacationists and tourists contribute an appreciable portion of the income from the basin.

CHAPTER II. PLANNING CONSIDERATIONS

In this chapter there are discussed the criteria, methods of analysis, and basic procedures used in planning and evaluating the possibilities for water resource development in the Upper Feather River Basin.

Engineering Considerations

The engineering studies conducted during this investigation were for the purpose of: (1) development of a basin-wide master plan for conserving the water resources of the basin for all beneficial uses; and (2) determination of the engineering feasibility of each major feature of the basin-wide plan of development.

The need for a basin-wide integrated plan for developing the water resources of a river basin arises from the relationship between the availability of water, the uses to which it can be placed, and the need for water in various parts of the basin. It is a recognized planning principle that to obtain optimum benefits from the development of the water resources of a river basin, individual projects must fit the broad outlines of a plan for developing the water resources of the entire basin. This principle was used in planning water conservation projects in the Upper Feather River Basin. Primary consideration was given to projects that would satisfy local water needs for agricultural, domestic, recreational, and fish and wildlife purposes. Secondary consideration was given to projects that would conserve the waters of the basin for hydroelectric energy production and that would satisfy water demands of areas located outside the basin.

A water project may have engineering feasibility if: (1) the water supply is adequate in quantity and quality; (2) sites for the dam, reservoir, conduits, and other facilities are geologically and topographically suitable; (3) the project can be constructed with available materials and techniques at a reasonable cost; (4) the climate and soils in a proposed service area are suitable for irrigated agriculture when this is a project function; and (5) the project is the best of the known alternatives.

In the following sections, the procedures used in determing the engineering feasibility of the possibilities for water conservation in the Upper Feather River Basin are described.

Water Supply

The following terms relating to water supply are defined for use in the ensuing discussion.

Annual--The 12-month period from January 1 of a given year through December 31 of the same year, sometimes termed the calendar year.

Seasonal--Any 12-month period other than the calendar year.

Precipitation Season--The 12-month period from July 1 of a given year through June 30 of the following year.

Runoff Season--The 12-month period from October 1 of a given year through September 30 of the following year.

Mean Period--A period chosen to represent conditions of water supply and climate existing during a long period of years. As it relates to runoff, it is the 53-year period from 1894-95 through 1946-47. As it relates to precipitation, it is the 50-year period from 1905-06 through 1954-55.

Base Period--A period for which reliable records are available, during which the conditions of water supply and climate are representative of those occurring during the mean period. For purposes of this bulletin, the base period chosen for irrigation studies was the 45-year period from 1911-12 through 1955-56. Average runoff during this period was about

91 percent for that of the mean period. The base period chosen for hydroelectric power studies was the 32-year period from 1920-21 through 1951-52.

Mean--The arithmetical average of quantities occurring during the mean period.

Average--The arithmetical average of quantities occurring during other than the mean period.

Natural Runoff--The flow of a stream as it would be if unaltered by upstream diversion, storage, import, export, or change in upstream consumptive use caused by man-made development. Natural runoff is reconstructed from measured runoff by allowing for the quantitative effect of alterations in stream flow above the point where the flow is measured.

Seasonal water supplies available for regulation for irrigation use at the reservoir sites selected in the Upper Feather River Basin were determined for the 45-year base period from 1911-12 through 1955-56. The use of this period was considered desirable for reservoir operation studies because: (1) precipitation and stream flow data were considered sufficiently complete to enable extrapolation of the existing records back to the 1911-12 season by correlation with records of comparable nearby stations having records for the desired period; (2) stream flow during the base period averaged about 91 percent of the flow for the 53-year mean period from 1894-95 through 1946-47; (3) a critically dry period from 1928-29 through 1933-34, during which average runoff was only about 54 percent of the runoff for the mean period, existed during the base period; and (4) other conditions of water supply and climate approximated mean conditions.

With regard to the sufficiency of precipitation and runoff data the following limitations are noted. Precipitation stations in, or adjacent to, the basin are not evenly distributed throughout the area. Only five of the 38 known stations are located above an elevation of 5,000 feet, but more than 50 percent of the area of the basin is located above this elevation. Also, only a few of the stream gaging stations in, or adjacent to, the Upper Feather River Basin have records for the entire 45-year base period. Records for most of the stations are of short duration or are intermittent. These limitations are typical of mountainous areas. However, correlation techniques enabled water supply estimates to be made with accuracy sufficient for purposes of this bulletin.

In compiling records of stream flow, the following procedure was used: (1) the natural runoff of the streams was estimated by correcting the existing records of runoff for historical upstream consumptive use, imports, exports, and storage; (2) where records for the entire 45-year base period were not available, they were extended by correlation with nearby streams having records for the full period; (3) where no stream flow records were available at a dam site being considered, natural flows were estimated by a multiple correlation of topographic, meteorologic, and hydrologic parameters; (4) separate correlations were made for each month of the year in order to establish the best estimate possible for intra-seasonal variations, and to make maximum use of records covering short periods or irrigation seasons only; and (5) the impaired flows available for storage during a 50-year repayment period of a project were computed by reducing the estimated natural runoff by both the present and estimated future upstream use which would occur during the project repayment period.

Natural Runoff at Dam Sites in the Middle Fork of the Feather River Basin. Following is a brief description of the methods used in estimating the natural runoff at each of the dam sites and points of diversion considered in the Middle Fork of the Feather River.

The natural runoff at the Grizzly Valley dam site on Big Grizzly Creek was determined to be substantially the same as that recorded at the gaging station on Big Grizzly Creek near Portola. It was necessary, however, to adjust the records for this station to account for the present consumptive use of water on lands that would be inundated by the proposed Grizzly Valley Reservoir. To obtain records for the entire 45-year period, the records for the Big Grizzly Creek gaging station were extended by direct correlation with the gaging station on the Middle Fork of the Feather River near Clio.

The water supply available for storage at Sheep Camp dam site on Carman Creek consists of the natural flow of Carman Creek, plus the diverted runoff from nine small stream basins located in the southwestern portion of Sierra Valley. There are no records for four of these small streams. The flows of the five remaining small streams are measured by the department's Watermaster Service during the irrigation season only. Runoff of these five streams was estimated by direct correlation with the recorded flows of Big Grizzly Creek and/or the flows of the Middle Fork of the Feather River near Clio. The runoff of the four ungaged streams was estimated from a correlation of topographic, meteorologic, and hydrologic parameters.

The natural runoff at Clio dam site is substantially the same as the runoff recorded at the gaging station near Clio. The records for this station were extended by direct correlation with the gaging stations on the Middle Fork of the Feather River near Nelson Point and at Sloat.

The natural runoff at Turntable dam site is substantially the same as the runoff recorded at the gaging station near Nelson Point. However, since this station had been in operation only from 1923 to 1932, it was necessary to extend the records by direct correlation with the records from stations at Sloat and near Clio.

The natural runoff at Nelson Point, Minerva Bar, Dogwood, Hartman Bar, and Bald Rock dam sites was estimated by a correlation of topographic, meteorologic, and hydrologic parameters of each subbasin. Monthly distribution of the seasonal runoff was made by correlating the runoff near Nelson Point with the recorded runoff at the gaging station on the Middle Fork of the Feather River near Merrimac. The runoff record near Merrimac had been previously extended by direct correlation with the recorded runoff at the gaging station on the Middle Fork of the Feather River at Bidwell Bar.

The natural runoff at the Red Ridge diversion dam site on Bear Creek, the Spoon diversion dam site on Little North Fork, and the Swayne dam site on French Creek, were computed from a correlation of topographic, meteorologic and hydrologic parameters. Monthly flows were then obtained by correlation with the flow recorded at the gaging station near Nelson Point.

Impaired Runoff at Dam Sites in the Middle Fork of the Feather River Basin Downstream From Sierra Valley. In developing estimates of the water supply of the Middle Fork of the Feather River that would be available for regulation by reservoirs located downstream from Sierra Valley, adjustments were made to the estimated natural runoff to reflect present and future water use in the area upstream from Sloat.

The difference between the estimated present and probable ultimate seasonal consumptive water requirements in the Middle Fork Basin of the Feather River is about 167,000 acre-feet which will be reflected as depletion of natural runoff. This depletion of the available water supply would result from the development of Frenchman, Grizzly Valley and Sheep Camp Projects, plus additional ground water development likely to occur in Sierra, Mohawk, and Long Valley. During the project repayment period of 50 years, it is expected that Frenchman and Grizzly Projects would cause an initial depletion of about 36,000 acre-feet per year. Some 25 years later when Sheep Camp Reservoir is completed, an additional depletion of 30,000 acre-feet a year would be probable. In addition, ground water development would cause further depletion but at a rate not now predictable. At the most, ground water depletion is not expected to exceed 50,000 acre-feet per season by the end of the repayment period. The average seasonal depletion at midpoint in time is estimated at 66,000 acre-feet.

Natural Runoff at Dam Sites in the North Fork of the Feather River Basin. Following is a brief description of the methods used in estimating the natural runoff at each of the dam sites considered in the North Fork Basin of the Feather River.

The natural runoff at the Abbey Bridge, Dixie Refuge, Antelope Valley, and Squaw Queen dam sites was estimated from a correlation of topographic, meteorologic and hydrologic parameters.

Monthly distribution of the estimated seasonal runoff at the Abbey Bridge dam site was made by direct correlation with the gaging station on Red Clover Creek near Genesee. Records for the Red Clover Creek gaging station had been previously extended by direct correlation with the gaging station on Indian Creek near Crescent Mills.

Percentage monthly distribution of the estimated seasonal runoff at the Dixie Refuge and Antelope Valley dam sites was assumed to be identical with the estimated percentage monthly flow at the Frenchman dam site on Little Last Chance Creek.

Percentage monthly distribution of the estimated seasonal runoff at the Squaw Queen dam site was made by direct correlation with the recorded flow at the gaging station on Indian Creek near Taylorsville. The record for this station was extended by direct correlation with the gaging station on Indian Creek near Crescent Mills.

The runoff at the Humbug dam site was considered to be directly proportional to the ratio of the drainage area above the dam site to the drainage area above the gaging station on Butt Creek above Almanor-Butt Creek Tunnel.

The runoff at the Meadow Valley dam site is recorded by the gaging station on Spanish Creek near Quincy. The records for this station were extended by direct correlation with the gaging station on Spanish Creek at Keddie.

Water Quality

The objective of the water quality studies was to evaluate present and to predict future water quality conditions in the Upper Feather River Basin. In making these studies, sources of impairment to the quality of surface and ground waters were considered. Also, mineral analyses of water samples were made to determine the suitability of the water for domestic, irrigation, fish and wildlife preservation, recreation, and hydroelectric power generation purposes.

Water quality analysis is a means of determining the characteristics of water which affect its use for beneficial purposes. The three types of analysis commonly made are: (1) mineral, involving a determination of the major inorganic constituents of the water; (2) physical, including determination of temperature, color, odor, and turbidity; and (3) sanitary, including biochemical, bacterial, and biological examinations. Consideration is given herein only to mineral quality.

Criteria presented in the following discussion can be utilized in evaluating mineral quality of water relative to existing or anticipated beneficial uses. It should be noted that these criteria are merely guides to the appraisal of water quality. Except for those constituents which are considered toxic to human beings, the criteria should be considered as suggested limiting values. A water which exceeds one or more of these limiting values need not be eliminated from consideration as a source of supply, but other sources of better quality water should be investigated.

Water quality standards for drinking water have been proposed by the United States Public Health Service and have been adopted by the State of California. These standards are shown in Table 2, which indicates the limiting concentrations of mineral constituents for drinking water.

TABLE 2

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1946

Mineral constituent	Concentration in parts per million
Mandatory Limits	
Lead (Pb)	0.1
Fluoride (F)	1.5
Arsenic (As)	0.05
Selenium (Se)	0.05
Hexavalent chromium (Cr^{+6})	0.05
Nonmandatory, but Recommended, Limits	
Copper (Cu)	3.0
Iron (Fe) and manganese (Mn) together	0.3
Magnesium (Mg)	125
Zinc (Zn)	15
Chloride (Cl)	250
Sulfate (SO_4)	250
Phenolic compounds in terms of phenol	0.001
Total solids, desirable	500
Total solids, permitted	1,000

Although hardness of water is not included in the drinking water standards, it is of importance in domestic and industrial uses. Excessive hardness in water used for domestic purposes causes increased consumption of soap and formation of scale in pipes and fixtures. Hardness classifications of water as suggested by the United States Geological Survey are presented in Table 3.

TABLE 3

DEGREE OF HARDNESS AND RELATIVE CLASSIFICATIONS OF WATER INTENDED FOR DOMESTIC OR INDUSTRIAL USE

Range of hardness, in parts per million	Relative classification
0 - 55	Soft
56 - 100	Slightly hard
101 - 200	Moderately hard
over 200	Very hard

Criteria for mineral quality of irrigation water have been developed at the University of California at Davis and at the Rubidoux Regional Salinity Laboratory of the United States Department of Agriculture. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters can be suggested.

The principal criteria for quality classification of irrigation waters are: total dissolved mineral solids, chloride concentration, percentage of sodium, and boron concentration.

Limits used for classification of irrigation water are presented in Table 4.

Class 1 irrigation water is suitable under most conditions for most crops. Class 2 irrigation water is of doubtful suitability, under certain conditions, for crops of low salt tolerance, including deciduous fruit, some vegetables and most clover grasses. Class 3 water is ordinarily unsatisfactory for all except the more tolerant plants, such as beets and salt-tolerant forage grasses.

TABLE 4

CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class 1, excellent to good	Class 2, good to injurious	Class 3, injurious to unsatisfactory
Total dissolved solids:			
In parts per million	Less than 700	700 - 2,000	More than 2,000
In conductance in micromhos/cm at 25°C	Less than 1,000	1,000 - 3,000	More than 3,000
Chloride, in parts per million	Less than 175	175 - 350	More than 350
Sodium, in percent of base constituents	Less than 60	60 - 75	More than 75
Boron, in parts per million	Less than 0.5	0.5 - 2.0	More than 2.0

These criteria have limitations in actual practice. In many instances a water may be wholly unsuitable for irrigation, under certain conditions of use, and yet be completely satisfactory under other circumstances. In irrigation use, soil permeability, drainage, temperature, humidity, rainfall and other conditions should be considered in addition to the quality classification of a water.

A high degree of water quality is necessary for the existence of the majority of food and game fish. Maintenance of a plentiful supply of food required by fish and wildlife is also dependent on a good quality water.

Various state and federal agencies have ascertained that water used for fish an aquatic life propagation should be free of excessive turbidity and toxic or harmful concentrations of mineral and organic substances. Water quality criteria for the maintenance of fresh water fish life have been suggested by the State Department of Fish and Game as follows:

1. Dissolved oxygen content not less than 85 percent saturation or five parts per million.

2. Hydrogen-ion concentration (pH) ranging between 7.0 and 8.5.

3. Ionizable salts, as indicated by conductivity, between 150 and 500 micromhos per centimeter at 25°C and, in general, not exceeding 1,000 micromhos per centimeter.

4. Ammonia not exceeding 1.5 parts per million.

Also, the State Department of Fish and Game has stated that fish and aquatic life are particularly susceptible to the following:

1. Mineral salts of high toxicity, such as mercury, copper, lead, zinc, cadmium, aluminum, nickel, trivalent and hexavalent chromium, and iron.

2. Detergents, poisons, and insecticides employed in agriculture.

3. Unusual temperature conditions. The normal range of water temperature for coldwater fish lies between 32°F and 65°F. For warmwater species, a temperature range from 45°F and 85°F with an absolute maximum of 91°F is generally considered acceptable.

4. Waste discharges containing more than 15 parts per million of other soluble material.

Since mineral content of water used for recreational purposes rarely presents a problem, there are at present no generally accepted criteria. Sanitary and aesthetic factors are, however, of major importance.

Problems of water quality of concern in the development of hydroelectric energy pertain chiefly to: (1) substances that accelerate corrosion; (2) debris, silt, and other suspended solids that block channels and intake devices or settle in reservoirs to reduce their useful storage; and (3) organic matter which decomposes and results in odors and the production of corrosive hydrogen-sulfide in reservoirs.

In the evaluation of water quality, office studies were made to select sampling points and to obtain data from review of existing reports. These studies were followed by field collection and analyses of surface and ground water samples. In addition, data on springs and wells were reviewed and possible sources of water quality impairment were located. Since it was not feasible to sample every spring and surface supply, representative samples were sought for each area or watershed. Standard mineral analyses were made of all samples collected during the investigation. In addition, samples collected from surface and ground water sources suspected of containing excessive mineral constituents were tested for heavy metals.

Reservoir Operation Criteria

The criteria used in conducting the reservoir operation studies discussed herein are considered in the following discussion. Terms used in this discussion are defined as follows:

Firm Irrigation Yield--The maximum sustained rate of draft from a reservoir that could be maintained through a critically deficient water supply period to meet a given demand for water with a permissible deficiency. For purposes of the studies conducted for the Sierra Valley service area, the firm irrigation yield was considered acceptable with an average deficiency of two percent per season and a maximum deficiency of 50 percent during one season of the base period. For the purposes of the studies for a portion of the Feather River service area on the Sacramento Valley floor, the maximum deficiency was limited to 35 percent during one season of the base period.

Project Power Capacity--The sum of the nameplate ratings of all the generation equipment installed on the project, exclusive of any overload capacity, and of any station service generators supplying the internal power requirements of the power plant and appurtenant facilities. Other power capacities that are significant and may be specified are dependable power capacity and nondependable power capacity.

Dependable Capacity--The load carrying ability that is always available for the time interval and period specified, when related to the characteristic of the load to be supplied. Dependable capacity is fixed primarily by the rate at which power can be produced under conditions of minimum head resulting from maximum reservoir drawdown, or maximum tailwater elevation, and the amounts of energy that can be produced during specified periods of time under the most adverse conditions. Certain and definite amounts of energy must be produced if the capacity is to be considered usable to supply that portion of the load assigned to a particular power plant.

Nondependable Capacity--The load carrying ability, over and above the dependable capacity, that is occasionally but not always available for certain specified time intervals and periods, and which is accompanied with sufficient energy to enable the capacity to be usable for limited applications such as for replacement of power that could otherwise be produced in steam-electric generating plants.

Capacity Factor--The ratio of the average dependable power required to be produced by a power generating plant to the dependable generating capacity of the plant. This may also be thought of as, and is numerically equivalent to, the proportion of the total time that the equipment would be operated at full dependable capacity to deliver the required equivalent energy.

Taxes Foregone--A term used to designate the amount of taxes that would not be collected as a result of a public agency power development rather than the most likely alternative development. Taxes foregone are equivalent to an amount equal to the taxes included in the fixed charges on an alternative steam-electric plant, and is the economic cost that is added to the annual cost of a hydroelectric power project that is to be constructed by a public agency when the economic justification of the project is being determined.

Estimates were made of average evaporation rates from free water surfaces to determine the monthly and seasonal net water losses from reservoirs due to evaporation. The estimated monthly net losses due to evaporation utilized in all reservoir operation studies are as follows: October, 2.4 inches; April, 2.4 inches; May, 4.8 inches; June, 6.0 inches; July, 8.4 inches; August, 7.2 inches; and September, 4.8 inches. The estimated seasonal net loss due to evaporation is 36.0 inches.

Reservoir sedimentation studies were cursory in nature and were limited to preliminary determinations of the amount of silt per square mile of drainage area that would be retained in reservoirs. Capacities were provided in reservoirs for the estimated accumulation of silt during the project life of the reservoirs.

Operation for Irrigation. Where water for irrigation use was planned as a purpose of a project, reservoir operation studies were made to determine the firm seasonal water yield that would be available to satisfy irrigation requirements. As stated previously, the period of study for the Sierra Valley service area was the 45-year base period from 1911-12 through 1955-56. The period of study for the Feather River service area in the Sacramento Valley was the 32-year base period from 1920-21 through 1951-52.

Three reservoirs were planned which would be operated to supply irrigation water for use in Sierra Valley. Under present conditions in Sierra Valley, a large portion of the water available for regulation is being diverted for irrigation use on the meadow lands in the project service areas. However, the method of application and the unfavorable time of occurrence of the natural flow, results in an inefficient operation in that only a small percentage of the applied water is beneficially used by growing crops. Regulation of the stream flow, therefore, would make possible a substantial increase in the amount of water which could be put to beneficial use. The increase in the amount of water which could be put to beneficial use would be the new yield of the project. To determine this increase, the amount of water beneficially used under present conditions was estimated. For this purpose, stream flows were considered usable in areas presently irrigated, to the extent of consumptive requirements and irrecoverable losses. Present beneficial use was found to vary considerably from season to season, since it was dependent upon the available water supply.

The monthly percentages of seasonal irrigation demand for Sierra Valley that were used for conducting reservoir operation studies are as follows: May, 3; June, 21; July, 34; August, 30; and September, 12.

An evaluation was made to determine the new firm irrigation yield that would be realized from the operation of the alternative Middle Fork Projects. The alternative Middle Fork Projects were operated disregarding the probable existence of Oroville Reservoir. The yield of new water on a firm irrigation demand schedule would be the difference in stream flow at Oroville during the irrigation season, with and without an alternative Middle Fork Project.

The yield of water that would be available from the alternative Middle Fork Projects on a firm irrigation yield basis was determined from analyses of reservoir operation studies of the alternative projects considered. The operation studies were conducted to determine the amounts of hydroelectric energy that could be realized from these projects and, therefore, the total yield of new irrigation water from these projects would be that which could meet an irrigation demand under a hydroelectric demand schedule. The month of June was shown to be the controlling month in determining the amount of new firm irrigation water that would be made available under a hydroelectric demand schedule. The estimated percentage of the total irrigation water needs that would be supplied in June was 19 percent. Therefore, the seasonal yield of new irrigation water would be about five times the yield available during the month of June. An analysis of the operation studies showed that June 1921, would be the controlling month during the 32-year operation period from 1920-21 through 1951-52. As stated previously, a maximum seasonal deficiency of 35 percent in any one season and an average seasonal deficiency of two percent during the 32-year period of operation, were allowed in determining the yield of new irrigation water.

Operation for Hydroelectric Energy Production. Where production of hydroelectric energy was planned as a purpose of a project, operation studies were conducted to determine the installed and dependable capacities of the power plants, and the seasonal production of energy in kilowatt-hours. The period of study was the 32-year base period from 1920-21 through 1951-52.

In the operation studies, it was assumed that all of the power plants would be operated as an integrated system, but the kilowatt-hour per kilowatt criteria, or monthly capacity factor, would be applied to each plant separately. Under this method of applying the criteria to each plant, the potential energy generation divided by the kilowatt-hours per kilowatt would be the capability of the plant, unless either the installed capacity of the plant or the head on the turbine was the limiting factor. In supplying its portion of the project dependable capacity, an individual plant could be operated to supply a different capacity each month. However, the sum of the capabilities of all of the project power plants would be at least equal to the project dependable capacity. Hence, for each kilowatt of project dependable capacity assigned to a plant, there would be sufficient energy generation to fulfill the minimum requirement; otherwise, the plant would not operate for the duration of that portion of the power load to which it would be assigned. Therefore, each plant would be operated at a monthly capacity factor at least equal to the minimum requirement. The operation studies were conducted using a capacity factor of 41.5 percent.

Operation for Flood Control. The operation of the reservoirs in the Upper Feather River Basin for the primary purpose of production of hydroelectric energy or the delivery of firm irrigation supplies would provide incidental flood protection to downstream areas. However, in these operation studies, no specific reservation of storage space was made for flood control purposes, but storage space above the ungated spillway crests would provide incidental protection by regulating the peak flows entering the reservoirs.

Operation for Recreation, and Fish and Wildlife. The operation of the projects would provide recreation, and fish and wildlife benefits. The authorized Indian Creek and the Genesee Recreation Projects would be operated for these purposes only. All other projects would be operated to provide multipurpose benefits and could thereby provide substantial recreational benefits.

In the operation of the projects, provision was made for minimum reservoir pools which would be sufficient to protect fish life. Also, stream flow maintenance releases were provided to maintain the existing fishery. In some cases, particularly the Indian Creek Recreation Project, stream flow releases were provided that would greatly enhance the existing fishery conditions. A discussion of the releases for stream flow maintenance purposes is presented in Chapter VI as a part of the description of each project, and is presented in detail in Appendix D, "Preliminary Evaluation of the Effect of the Upper Feather River Basin Development on Fish and Wildlife". Appendix D was prepared by the Department of Fish and Game.

Geologic Investigations

The geologic exploration program in the Upper Feather River Basin included: (1) geologic mapping of dam and reservoir sites, potential borrow areas, and conduit routes; (2) foundation test drilling and trenching; (3) petrographic analysis of foundation rocks; (4) seismic and resistivity exploration to determine the depths to water table and to bedrock; (5) collection of soil samples for testing to determine the construction properties of available materials; and (6) determination of quantities of available construction materials. In studying the sites, emphasis was placed on the determination of rock types, degree of weathering, patterns of jointing, the nature and extent of shear zones, and the engineering properties of the foundations. The program varied from reconnaissance investigations of surficial geologic features at some sites to detailed subsurface investigations at other sites, in accordance with the size and significance of the proposed structures, and with the geologic problems encountered.

Complete reports on the results of the geologic exploration of the various sites are available in the files of the Department of Water Resources. These reports include drill hole logs, test results, geologic maps and cross-sections, maps of locations of construction materials, and results of seismic and resistivity surveys.

Designs and Cost Estimates of Structures

Engineering designs were made of several sizes and types of dams for each of the sites considered to determine estimates of capital and annual costs of the required structures. Structures were designed in accordance with standard engineering principles with the objective of obtaining the most economical combination of dam embankment, spillway, and outlet works. The dams would be constructed with available natural material where possible. Stability characteristics of the earth embankments were based on laboratory tests of sampled materials. In general, design floods were routed through the reservoirs and spillways were sized to safely pass peak outflows.

Estimates of the capital costs of each project include construction costs of the dam and appurtenances, acquisition of land for reservoir and dam sites, and relocation of utilities. Capital costs are based on unit prices prevailing in 1959. Also included are allowances of 10 percent of the total cost for engineering and administration, and 15 percent of the total cost for contingencies in construction. Interest during construction was added to the capital cost in the amount of 4.0 percent per annum for one-half of the construction period. Annual costs include amortization of the capital investment at an interest rate of 4.0 percent with a repayment period of 50 years and the annual outlay required for replacement, operation, and maintenance, and general expense.

It is believed that the features of the projects as presented herein reasonably represent those which would be selected for construction to meet the stated accomplishments. Changes in design would probably be made after further exploration of the sites and more thorough design analysis. It is noted, however, that because of the present limited knowledge of the geologic conditions at the dam sites in the Middle Fork of the Feather River, substantial changes in design and estimates of cost for developing the Middle Fork might occur when additional information is made available.

Appraisal of Lands

Preliminary estimates were made of the value of lands, improvements, and utilities within the reservoir sites under consideration. Real estate was evaluated by the market analysis method in which each tract of land is appraised by comparison with recent transactions of similar property. Data on land ownership and descriptions of properties were obtained from the county assessor. Data on recent sales and costs of properties, in and adjacent to the areas, were obtained from county recorders and from local real estate agencies.

Estimates of the value of improvements and utilities were based upon replacement costs. Improvements include buildings, structures, private water systems, and private irrigation works. Utilities include highways, roads, telephone and electric power lines, municipal water works, and irrigation service agency works. Replacement costs were estimated as the expenditure required under existing conditions to replace a structure with a similar one of comparable utility.

It was assumed that the market value of lands represents the present worth of future productivity on lands flooded by reservoir development.

Estimates also were made of damage that might accrue to a property owner because of construction of a project. These estimates of damage include costs for severance of property, reduction of area of operation, loss of, or obstruction to, communications, loss of arable lands by reason of flooding, and other elements.

Surveys and Maps

Topographic maps of the Frenchman, Grizzly Valley, and Nelson Point reservoir sites were obtained from the United States Bureau of Reclamation. Topographic maps of the dam sites in the Middle Fork of the Feather River below Nelson Point were obtained from the Richvale Irrigation District. All other topographic maps of reservoir and dam sites were prepared by the Department of Water Resources during the course of the investigation.

Reservoir site maps were prepared at a scale of one inch equals 400 feet, with a contour interval of 20 feet. Dam site maps were prepared at a scale of one inch equals 100 feet, with a contour interval of five feet. Other maps used in the investigation were United States Geological Survey quadrangles at a scale of 1:62,500. The contour intervals for these maps vary from quadrangle to quadrangle.

Economic Considerations

The principal economic studies conducted to evaluate the possibilities for developing the water resources of the Upper Feather River Basin were: (1) determination of project benefits that would accrue from the construction of the potential projects; (2) project formulation and evaluation studies to determine the size and the economic justification of the potential projects; and (3) financial feasibility studies of the initial units proposed for construction. The latter studies were conducted only for Frenchman and Grizzly Valley Projects and Indian Creek Recreation Project. Results of these studies were published in Bulletin No. 59, "Investigation of Upper Feather River Basin Development, Interim Report on Engineering, Economic, and Financial Feasibility of Initial Units" (February 1957).

Project Benefits

Benefits from the projects considered would accrue primarily from new and reregulated irrigation water supplies, flood control, production of hydroelectric energy, and new recreational opportunities.

Irrigation Benefits. By means of irrigation it is possible to obtain a greater crop yield in the agricultural areas of the Upper Feather River Basin than is possible under dry-farm operations. Present irrigation development in this area reflects maximum use of the unregulated surface water supply and limited use of the ground water supply. Under project development, water made available for irrigation purposes would comprise regulation of natural flows plus new project water. Both regulated and new water released to project service areas would provide a basis for increased agricultural income to local ranchers. The increased returns to land made possible by the new and reregulated water supply would represent the measure of benefit to the water users, and would provide the source of funds for repayment of costs allocated to the irrigation function of projects considered.

In connection with earlier investigations of the Upper Feather River, preliminary estimates of the benefit to be derived from the provision of new or reregulated water were made. This investigation indicated that there would be a continuation of the livestock economy in the area. This original conclusion is believed to be correct in the light of further investigation of the area. However, the intensity of future land use under a livestock economy is believed to be somewhat less than earlier studies had indicated. Discussion of farming practices with ranchers in the area, together with an examination of the ownership pattern, have led to the conclusion that the intensity of land use will more closely resemble the present production of meadow pasture and meadow hay.

These earlier studies, particularly for the Frenchman and Grizzly Valley service areas, indicated an average net benefit of about $9.00 per acre-foot of water. This value was derived by use of price and cost data for the 10-year period from 1946-56 when the parity ratio was about 100. Recently, in connection with other studies being made by the department, re-analysis of the probable benefits of water service in Sierra Valley has been completed. This analysis was done on the basis of price and cost data for the period from 1952-56, when the parity ratio was about 88 and was made in accordance with current procedures of the Department of Water Resources and of land use plans currently being considered by the water users. This analysis indicates irrigation benefits of about $6.50 per acre-foot.

The Sheep Camp service area, which was not evaluated in the previous study, can be expected to provide irrigation benefits of about the same magnitude as other portions of the Upper Feather River service area or about $6.50 per acre-foot for new water, assuming that water can be provided for a price which is within the financial capacity of the water users. Benefits attributable to the reregulation of the 23,000 acre-feet of water from the Sheep Camp Project, presently being put to beneficial use, were estimated to be $2.00 per acre-foot.

Irrigation benefits from the alternative Middle Fork Projects would be realized from the new water supplies that could be made available on a firm irrigation demand schedule to the Feather River service area on the Sacramento Valley floor. Agricultural economic studies conducted in connection with the evaluation of Oroville Reservoir have shown that new firm irrigation water supplies in the Feather River service area would have an average net benefit of about $11.00 per acre-foot. However, it appears probable that water from any of the alternative Middle Fork Projects would be used on lands having somewhat lower than average productive capabilities. On the premise that 65-70 percent of the lands to be supplied with water from any of the Middle Fork Projects would be used for rice and the remaining 30-35 percent for various field crops, irrigation benefits of the general magnitude of $8.00 per acre-foot could be expected. This again assumes that water could be provided within the ability of the water users to meet water costs. For the purposes of this investigation, irrigation benefits were estimated to be $8.00 per acre-foot of water.

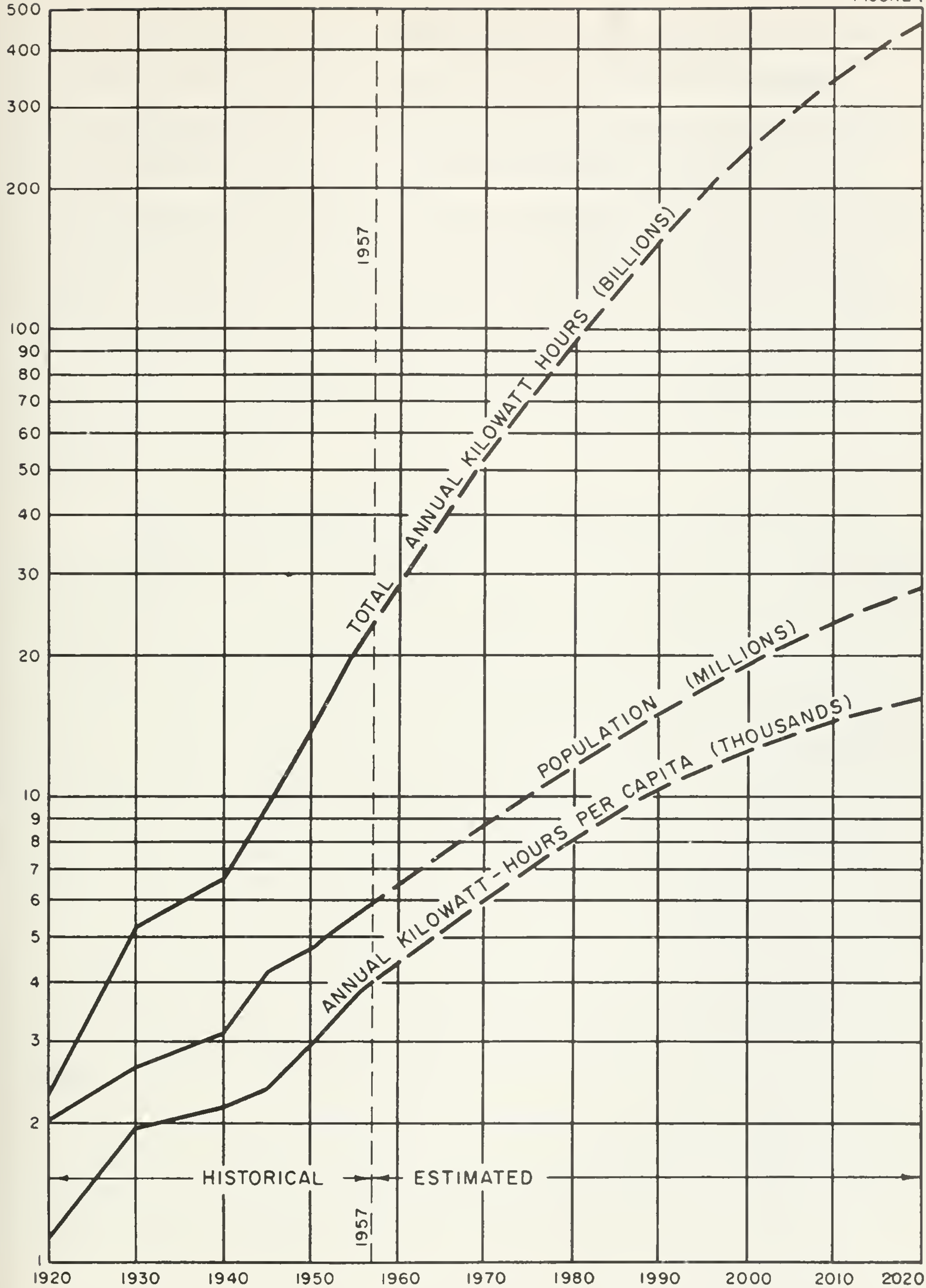
Hydroelectric Power Benefits. Hydroelectric power benefits were measured in terms of the cost of producing power by the most likely alternative source; in this case, a privately financed, steam-electric plant. Emphasis was placed on estimating the market for, and the value of, hydroelectric power since these factors are of primary importance in forecasting future revenues attributable to any power project. A general description of the factors considered and the results obtained are presented in the following discussion.

Northern and Central California were selected as the power market area. The anticipated magnitude and characteristics of future power demand in this area were related to the estimated generating resources available to meet this demand. The area load and resource projections were analyzed to ascertain the proper relationship between dependable generating capacity and the average annual energy generated for the power plants to be added by the projects considered herein. Power revenues were estimated after the magnitudes of the dependable capacity and average annual energy generation were determined.

It was concluded from detailed technical studies that future power requirements of Northern and Central California, based on anticipated population growth and annual energy use per capita, would provide a ready market for hydroelectric power generated by the projects considered herein. Figure 1 illustrates the historical and estimated future population, energy use per capita, and total energy requirement for Northern and Central California.

The interconnected power systems of Northern and Central California comprise an integrated power supply system of hydroelectric and steam-electric generating capacity. The hydroelectric plants are generally used for peaking service, whereas the continuous base load is largely supplied by steam-electric plants. The present dependable generating capacity of the system for the month of August in an adverse water year totals about 5,700,000 kilowatts. Of this amount, 2,600,000 kilowatts are generated by hydroelectric plants and 3,100,000 are generated by steam-electric plants. It is anticipated that approximately 2,000,000 kilowatts of dependable hydroelectric capacity and 3,000,000 kilowatts of steam-electric capacity will be added to the system by 1970. Although estimating additions to hydroelectric generating capacity after 1970 is highly speculative, it is anticipated that another 2,000,000 kilowatts of dependable hydroelectric capacity will be added to the system between 1970 and 1980. Additional steam-electric capacity of 6,500,000 kilowatts would be added to meet the system load.

With the power requirement increasing at the rate indicated above, a market for the energy output of hydroelectric plants is assured. Of primary importance to the amount of revenue that can be realized from a hydroelectric plant, however, is the degree of peaking that can be absorbed into the system. The ratio of steam-electric power to hydroelectric power will steadily increase as sites for hydroelectric plants become scarce. As a consequence, hydroelectric power will be utilized for peaking purposes to a greater degree than is the case today. However, for purposes of this investigation, hydroelectric plants were designed for a moderate degree of peaking, as would be the case if they were constructed for near future market conditions.



HISTORICAL AND ESTIMATED FUTURE POPULATION AND PER CAPITA AND TOTAL ENERGY GENERATION NORTHERN AND CENTRAL CALIFORNIA

It was assumed that power generated from the projects considered herein would be sold at the 230 kilovolt bus at the Oroville switchyard. Based on the estimated cost of publicly financed transmission facilities from Oroville to the load center, and the cost of producing equivalent power in a modern steam-electric plant, the value of hydroelectric power at the Oroville switchyard was estimated as follows: capacity component, $22.80 per year per kilowatt of dependable capacity; and energy component, 3.0 mills per kilowatt-hour. The power output from the system of plants for each plan was reduced by three precent to allow for transmission losses from power plant sites to the Oroville switchyard.

Flood Control Benefits. Although some degree of incidental flood control to downstream areas probably would be realized from each of the projects considered herein, the annual benefits would be small in most cases. The limitation would result from the small proportion of the total runoff which could be controlled and from the relatively small amount of damage that occurs under present conditions. The principal exception to this would be Frenchman Reservoir currently under construction. This reservoir would provide flood control to the lands along Little Last Chance Creek in Sierra Valley. Flood control benefits to this area were evaluated as described in Bulletin No. 59.

The value of incidental flood control benefits achieved from reservoir storage would be the difference between the losses from damages under present conditions and the losses from damages under project conditions. Damage to agricultural lands accounts for the major portion of the losses and occurs mainly in the form of stream bank and sheet erosion; from deposition of debris in channels, ditches, and fields; from loss of irrigation structures and fences; and from inundation of meadow lands.

Probable flood flows under project conditions were estimated from flood routing studies, with surcharge storage above the spillway crest utilized for flood control. Inflow hydrographs of various frequencies were derived from unit hydrographs and flow-frequency curves estimated from stream flow records. After routing inflow through the reservoir, the resultant estimated flood flows were applied to the previously established flow-damage relationship to estimate damage under project conditions.

Recreation Benefits. Because of the importance of recreation to the economy of the upper basin, certain projects were planned that would be almost entirely recreational in nature. For these projects, and for others in which significant recreational use was forecast, recreational benefits were estimated in monetary terms to facilitate comparison of alternative proposals and to make benefit-cost analyses.

Recreational benefits attributable to the facilities studied were estimated by applying a monetary value per day of recreational use to the days of public recreational use forecast over the economic life of the project. In the evaluation of recreational benefits, consideration was given to the recreational potential of streams below reservoir sites, and the recreational potential of the reservoir sites and land adjacent thereto.

The recreational potential of streams affected by the various projects considered was evaluated by the Department of Fish and Game in terms of present and future angler-days of use. Present use was determined by sampling surveys, interviews, and by counts of angling intensity and distribution.

Future use of streams affected by project development was projected to an estimated saturation in the year 2050. The development trend allowed reasonable time for growth of facilities, for improvements in transportation and access, and for an increase in leisure time. Separate forecasts were made for conditions with and without each project. The difference in the forecasts represented the use of visitor-days creditable to the potential water project.

A report containing recommendations regarding stream flows and prepared by the Department of Fish and Game, is included herein as Appendix D. The firm of Pacific Planning and Research, consultants in planning and urban economics, was retained by the department to determine the recreational benefits from the Upper Feather River Basin that could be realized from possible water projects. This determination was made by estimating the visitor-days of recreational use that would accrue to each project and then converting these visitor-days of use into monetary terms.

Although it is anticipated that both public and private recreational facilities would surround the proposed reservoirs, it was considered that the justification for public investment should be restricted only to those benefits derived from public facilities. It was further considered that to encourage and aid full recreational development, initial basic facilities, such as access roads, sanitary facilities, drinking water, and public camp grounds, would be provided by public funds. Likewise, to control development for the greatest public use, it was considered that all potential recreational lands adjacent to the reservoir sites would be zoned in the public interest. This could be accomplished either by purchase of the land, or by use-permit if the land is in federal ownership. Later operational policies would decide the allocation of land for private and public use, and the administrative procedure to be followed.

A report on the studies of the firm of Pacific Planning and Research was published in July 1959, as Appendix A, "Recreational Benefits from Upper Feather River Basin Development".

Project Formulation and Evaluation

Project formulation and evaluation studies were conducted to determine the proper size and economic justification of the potential projects in the Upper Feather River Basin.

Project Formulation. Each project was selected and sized to provide the most economical method of accomplishing its purpose and to provide maximum net benefits. The optimum level of development for the projects considered in this bulletin is that size of project at which the incremental benefits equal the incremental costs. The value of the benefits utilized in the sizing studies was limited to the primary irrigation, power, and flood control benefits. The costs used in the sizing studies included all project costs, and costs for operation, maintenance, and replacement.

Recreational benefits from potential multipurpose projects, although considered to be primary in nature, were not used in sizing studies due to the difficulty in determining modifications in recreational benefits for different reservoir sizes. For this reason, economic sizing studies of potential reservoirs that would be operated primarily for recreational purposes were not made. The size of these projects was based on considerations of reservoir water depths necessary to maintain optimum water temperatures for fish and plant life, water yields for stream flow enhancement releases, minimum cost per acre of reservoir water surface, length and preservation of shoreline features, and location of natural features affecting placement of structures

Economic Justification. A project may be considered to be economically justified when the benefits that accrue therefrom are in excess of the costs incurred in its design, construction, operation and maintenance. Also, each separate segment or purpose of a multipurpose project must provide benefits at least equal to its cost. The comparison of the benefits and costs of a project is commonly expressed as a benefit-cost ratio. This should not be the only criterion, since such a ratio does not adequately reflect many project intangible benefits or detriments which may be of substantial significance.

In making justification analyses of potential projects in the Upper Feather River Basin, only tangible primary benefits were utilized. A tangible benefit is one that can be adequately expressed in monetary terms, whereas an intangible benefit, although real, cannot be so measured. A primary benefit is the net gain or value realized directly from the project. A secondary benefit is the net gain or value added, over and above the values of the primary benefit, due to processing or other activities over and above those of the primary beneficaries.

In determining the economic justification of potential hydroelectric power projects, taxes foregone were included as an economic cost.

Financial Feasibility

Financial feasibility studies were conducted for the initial units of the Upper Feather River Basin development. Determination of financial feasibility of projects included: (1) allocation of costs among the various project purposes; (2) consideration as to what organization or agency should bear the allocated costs; and (3) consideration of the ability and the willingness of the organization or agency to repay such costs. These studies were described in Bulletin No. 59.

CHAPTER III. LEGAL ASPECTS

Adequate water rights are a necessary prerequisite to the construction of any water development project, whether large or small, which involves storage or direct diversion of surface water for use on nonriparian land. Prior to December 19, 1914, the effective date of the Water Commission Act, a water right could be initiated simply by using the water and the right could be made a matter of record by filing a notice with the county recorder. Since that date, initiation of appropriative rights must be made by filing an application with the State Water Rights Board, or one of its predecessor agencies. If unappropriated water is available and other requirements are met, a permit is issued, and after use of water is complete, the rights are confirmed by a license. The priority of the rights is as of the date on which the application is filed.

The following definitions are included to aid in understanding the discussion of water rights:

State Applications--A state application is an application filed by the Department of Water Resources or its predecessor pursuant to Water Code Section 10500. This section authorizes the department to file an application for any water which, in its judgment, may be required in the development and the completion of the whole or any part of a general or coordinated plan looking toward the development, utilization, and conservation of the State's water resources. These applications have been filed periodically since 1927 for projects which involve the water of streams of the State of California, both for export projects and local development. The effect of such state applications is to hold rights to the use of water in public trust for future use.

Release From Priority of State Applications--Under Water Code Section 10504, the California Water Commission is authorized to release from priority any portion of a state application in favor of applications of a junior priority. In general, a release from priority may be made to an agency contemplating a water development project on a stream on which a state application has been filed, where the agency's project contemplates different works or envisions either a purpose of use or a service area not covered by the state application.

Assignment of State Applications--In general, an assignment of a state application is made pursuant to a request by an agency contemplating a water development project on the same stream system on which a state application has been made. Such assignment is authorized by Water Code Section 10504, and is made in the case where the constructing agency proposes to construct the project along the lines of that set forth in the state application.

Requirements of Diligence--Any application (except state applications which have not been assigned) and permits that have been issued pursuant to approved applications are subject to the requirements of diligence as set forth in Part 2 of Division 2 of the Water Code, and the rules and regulations of the State Water Rights Board. These provisions require the applicant to complete an application on file with the State Water Rights Board diligently, the permittee to complete construction of the physical works required to apply the water to beneficial use with due diligence, and the licensee to continually apply the water to the uses in accordance with the terms and conditions of the license. Failure to comply with the requirements of diligence can result in the cancellation of an application or the revocation of a permit or license. All unassigned applications filed by the State pursuant to Section 10500 of the Water Code including those for the Feather River and Delta Diversion Projects have been relieved from the regular requirements of diligence over the years by periodic exemptions by the Legislature. The present exemption expires on October 1, 1963.

State Applications

The Legislature, during its 1927 session, enacted Chapter 286, Statutes of 1927, which is now codified in Part 2 of Division 6 of the Water Code. Section 10500 of this part of the Water Code reads, in part, as follows:

> "10500. The department shall make and file applications for any water which in its judgment is or may be required in the development and completion of the whole or any part of a general or coordinated plan looking toward the development, utilization, or conservation of the water resources of the State . . ."

Under the authority vested in it by the preceding section, the Department of Water Resources has filed six water rights applications in furtherance of the Upper Feather River Basin development. Applications Nos. 16950 through 16954 were filed on March 20, 1956, and Application No. 18844 was filed on July 6, 1959.

Applications filed by the State may be assigned or may be released from priority in favor of junior applications. This authority is vested in the California Water Commission by Section 10504 of the Water Code which reads as follows:

"10504. The commission may release from priority or assign any portion of any appropriation filed under this part when the release or assignment is for the purpose of development not in conflict with such general or coordinated plan. The assignee of any such application, whether heretofore or hereafter assigned, is subject to all the requirements of diligence as provided in Part 2 of Division 2 of this code. 'Assignee' as used herein includes, but is not limited to, state agencies, commissions and departments, and the United States of America or any of its departments or agencies."

An assignment or release from priority does not give the recipient perfected water rights. After an assignment has been made, the recipient will generally have to complete the application before the State Water Rights Board so as to include the details of the proposed project. The application is then advertised by the board and an opportunity provided for protests. A hearing is then held by the State Water Rights Board concerning the issuance of a permit on the application. Protestants and other interested parties can present evidence. The Department of Water Resources under Section 184 and 1256 of the Water Code usually appears at such a hearing to present information it deems pertinent. Subsequent to the hearing, the State Water Rights Board determines whether a permit should be issued and generally includes in any permit various conditions concerning the project. Following the issuance of the permit, the permittee proceeds with construction and application of the water to beneficial use. Releases from priority of state applications in favor of the applications of one proposing to build a project may be made before or after permits have been issued on his applications, but otherwise the procedure is the same.

Pursuant to provisions of Chapter 2099 and 2101, California Statutes of 1959, the California Water Commission is required to hold hearings on any request for an assignment or release from priority of any state application. The Commission must give a 60-day notice to all counties affected by the project. In order to obtain the assignment of a state application in the capacity of constructor of a water project, the department is required to proceed in the same manner as any other agency. A hearing must be held to determine whether an assignment should be made and what conditions should be included in it. After an assignment is made, the department must proceed to perfect the application before the State Water Rights Board and to put water to beneficial use under it.

In the event of amendments to applications for assignment or release, Section 10504.5 of the Water Code provides as follows:

> "10504.5. In order to insure that projects will be constructed in accordance with a general or co-ordinated plan for the development of water:
>
> "(a) The recipient of a release from priority or assignment under this part shall, before making any changes determined by the California Water Commission to be substantial in the project in furtherance of which the release or assignment was made, submit such changes to the California Water Commission for its approval. The commission shall approve any such change only if it determines that such change will not conflict with the general or co-ordinated plan. All permits and licenses issued pursuant to applications so released or assigned shall contain terms conditioning such permits and licenses upon compliance with this subdivision.
>
> "(b) The holder of applications that have been assigned, or in favor of which a release from priority has been made, shall submit any proposed amendments to such applications to the commission before their submission to the State Water Rights Board. The commission shall approve such amendments only if it determines that the amendments will not conflict with the general or co-ordinated plan. The commission shall notify the holder of the application and the State Water Rights Board of its approval or disapproval. No amendments to any such application shall be authorized by the State Water Rights Board unless they are first approved by the commission.
>
> (Added by Stats. 1958, Ch. 2101)"

County of Origin Law and Watershed Protection Act

The County of Origin Law and Watershed Protection Act can best be understood in the light of the physical situation with which they were designed to deal. The physical problem is relatively simple and readily understandable. It is brought about by the maldistribution of the State's water supplies, both as to area and time of occurrence. Approximately 70 percent of the State's water supplies originate in the area north of the latitude of Sacramento. Conversely, approximately 70 percent of the ultimate need for water will occur south of that latitude. Hence, water must be transferred from north to south. In addition, practically all of the rain and snowfall occurs in the winter and spring months and must be stored in reservoirs in order to make it available for use during the summer and fall months, either in the local areas or in areas to which water is exported. Furthermore, there are wet years and series of wet years during which water must be stored for use during dry years.

From an engineering standpoint, these physical difficulties can be overcome by constructing dams and reservoirs to conserve the winter and wet year flows, and by constructing aqueducts, pumping plants, and distribution systems to convey the water, and to make it available for use both in areas of origin and in areas of deficiency. There are, however, additional practical considerations which make the problem more complex. These are the legal, financial and other considerations, which are part of the interplay of interests in our democratic-type of government.

Plans for taking large quantities of water from one area to another have resulted in the fear on the part of the areas of surplus that there will not be adequate water remaining for their future needs. In 1931, the County of Origin Law was enacted to offer protection to the counties of water surplus. This law, now Section 10505 of the Water Code, placed a restriction on the State in assigning or releasing any water rights application filed by the State in furtherance of a general plan to develop the State's water supplies. Section 10505 of the Water Code provides as follows:

> "10505. No priority under this part shall be released nor assignment made of any appropriation that will, in the judgment of the commission, deprive the county in which the appropriated water originates of any such water necessary for the development of the county."

This protection has three principal limitations: first, it is only effective as to applications of the State; second, it is dependent upon periodic relief by the Legislature from the usual requirements of diligence which apply to all other applications; and third, it applies only to water originating within a county.

Subsequently, the Legislature passed the Watershed Protection Act as part of the Central Valley Project Act. These provisions restrict the operators of the Central Valley Project by requiring that no watershed wherein the water originates, or no area immediately adjacent thereto which could be conveniently served with water therefrom, shall be deprived of necessary water by the project. These provisions constitute Sections 11460-11463 of the Water Code, supplemented by Section 11128. Section 11460, the most important of these sections, reads as follows:

> "11460. In the construction and operation by the department of any project under the provisions of this part a watershed or area wherein water originates, or an area immediately adjacent thereto which can conveniently be supplied with water therefrom, shall not be deprived by the department directly or indirectly of the prior right to all of the water reasonably required to adequately supply the beneficial needs of the watershed, area, or any of the inhabitants or property owners therein."

While in one sense broader than the County of Origin Law, the watershed sections are also restrictive in their protection in that they apply only to the operators of the Central Valley Project.

In 1955, the Attorney General of California issued two opinions construing the County of Origin Law and Watershed Protection Act (25 Ops. Cal. Atty. Gen. 8; 25 Ops. Cal. Atty. Gen. 32). Among the conclusions reached were the following:

> (1) "Water Code Sections 10505, 11460, and 11463, properly construed and applied, do not violate article XIV, section 3, of the California Constitution."
>
> (2) "In the circumstances specified in the statute, Water Code Sections 10505 and 11460 would require that water which had been put to use in the operation of the Central Valley Project in areas outside the county of origin, or the watershed of origin and areas immediately adjacent thereto, be withdrawn from such outside areas and made available for use in the specified area of origin."
>
> (3) "An assignment of the Feather River applications conditioned by a general reservation of all the water originating in any county of origin which is necessary for development of that county would not constitute a delegation of any mandatory statutory duty . . ."

The several releases from priority and assignments executed since 1927 have usually contained a clause reserving a specified amount of water for the county of origin or a general reservation without attempting to specify a definite quantity. Releases and assignments granted recently have, in nearly all cases, contained a general reservation of water for the future development of the counties of origin.

The Feather River and Delta Diversion Projects are subject to both the County of Origin Law and Watershed Protection Act. Since these projects will rely on state applications, it will be necessary to include appropriate conditions in the assignments of applications made to the Department of Water Resources as constructor of these projects that will reserve for the counties of origin water that may be necessary for their development.

As provided in Water Code Sections 11260 and 11270, the Feather River and Delta Diversion Projects are part of the Central Valley Project. They are, therefore, also subject to the limitations of Water Code Sections 11460 and 11463, the area of origin provisions. As a result, these projects cannot be operated so that any watershed in which water originates, or any area immediately adjacent to such a watershed that can conveniently be served with water, is deprived of water required to supply its needs.

Any release from priority or assignment of state applications for a project to be constructed in the Upper Feather River Basin must be such that it will not deprive the counties of origin of water that they require for their development. Where the intended use is outside the county of origin, adequate protection can usually be furnished by including in the release or assignment either a general or specific reservation of water for use within such county. Developments contemplated by others than the State in the Upper Feather River Basin are not subject to the Watershed Protection Act, since they are not units of the Central Valley Project. These applications are discussed in detail later in this chapter.

State Applications for the Feather River and Delta Diversion Projects

Since 1927, the State of California, pursuant to Water Code Section 10500, has filed 15 water rights applications in furtherance of the authorized Feather River and Delta Diversion Projects. These applications are now on record with the State Water Rights Board. The first two of the applications were filed by the State in 1927 and were numbered 5629 and 5630. These applications were made in furtherance of the Feather River Unit of the State Water Plan. In 1951, three additional applications, numbered 14443, 14444, and 14445, were filed in furtherance of the Feather River and Delta Diversion Projects as described in the 1951 report on these projects. The next group of applications, numbered 16950 through 16954, was filed in 1956 in furtherance of the plans for water development as set forth in the "Report on the Upper Feather River Service Area", April 1955. Four applications for the Delta Diversion Projects were filed in 1957 and are numbered 17512 through 17515. Applications Nos. 17512 and 17513 propose diversions from the Italian Slough in the Sacramento-San Joaquin River Delta, and Applications Nos. 17514 and 17515 propose diversions from Lindsey Slough in the Sacramento-San Joaquin River Delta. In 1959, Application No. 18844 was filed for additional storage in Frenchman Reservoir. The essential features of these 15 applications are summarized in Table 5.

TABLE NO. 5

STATE APPLICATIONS FOR THE FEATHER RIVER AND DELTA DIVERSION PROJECTS

Application No.	Source of water and name of facility	Date filed	Amount of application: Direct diversion, in second-feet	Amount of application: Storage, in acre-feet	Purpose
5629	Feather River (Oroville Reservoir)	7-30-27	7,600	380,000	Power
5630	Feather River (Oroville Reservoir)	7-30-27	1,400	380,000	Irrigation, domestic, salinity control, flood control, navigation, and fish and wildlife enhancement
14443	1)Feather River 2)Delta Channels (Oroville Reservoir and Delta Diversions)	8-24-51	1,360 6,185	3,500,000 42,100	Irrigation, domestic, municipal, industrial, recreational, flood control, salinity control, navigation, and fish and wildlife enhancement

TABLE NO. 5 (continued)

STATE APPLICATIONS FOR THE FEATHER RIVER AND DELTA DIVERSION PROJECTS

Application No.	Source of water and name of facility	Date filed	Amount of application: Direct diversion, in second-feet	Amount of application: Storage, in acre-feet	Purpose
14444	Feather River (Oroville Reservoir)	8-24-51	11,000	3,500,000	Power
14445	1)Feather River 2)Italian Slough (Oroville Reservoir and Delta Diversions)	8-25-51	2,140 8,000	600,000	Irrigation, domestic, municipal, industrial, recreational, flood control, saline control, navigation, and fish and wildlife enhancement
16950	Big Grizzly Creek (Grizzly Valley Reservoir)	3-20-56		49,000	Irrigation, municipal, stream maintenance, and recreational
16951	Indian Creek (Antelope Valley Reservoir)	3-20-56		18,200	Stream maintenance and recreational
16952	Little Last Chance Creek (Frenchman Reservoir)	3-20-56		30,000	Irrigation and recreational
16953	Last Chance Creek (Dixie Refuge Reservoir)	3-20-56		14,300	Recreational and stream maintenance
16954	Red Clover Creek (Abbey Bridge Reservoir)	3-20-56		8,400	Recreational and stream maintenance
17512	1)Italian Slough or 2)San Luis Creek (San Luis Reservoir)	3-15-57		1,100,000	Irrigation, domestic, recreational, municipal, industrial, and fish and wildlife enhancement
17513	Italian Slough (South Bay Aqueduct)	3-15-57		26,500	Irrigation, domestic, municipal, industrial, and recreational

TABLE NO. 5 (continued)

STATE APPLICATIONS FOR THE FEATHER RIVER AND DELTA DIVERSION PROJECTS

Application No.	Source of water and name of facility	Date filed	Amount of application: Direct diversion, in second-feet	Amount of application: Storage, in acre-feet	Purpose
17514	Lindsey Slough (North Bay Aqueduct)	3-15-57	900		Municipal and domestic
17515	Lindsey Slough (North Bay Aqueduct)	3-15-57	900		Irrigation and domestic
18844	Little Last Chance Creek (Frenchman Reservoir)	7-6-59		20,000	Domestic, irrigation, stockwatering and recreational

Applications Nos. 16950 through 16954, as indicated, were filed in furtherance of the plans for the development of the Upper Feather River Basin as envisioned in the 1955 report of the Division of Water Resources on the Feather River and Delta Diversion Projects. The projects covered under these five applications are Grizzly Valley, Antelope Valley, Frenchman, Dixie Refuge, and Abbey Bridge Dams and Reservoirs. In addition to these applications, Application No. 18844 was filed for 20,000 acre-feet of additional storage at Frenchman Reservoir. The essential features of the six applications are described in the following paragraphs.

Application No. 16950 proposes the appropriation of 49,000 acre-feet per annum from Big Grizzly Creek. Water sought under this application would be stored in Grizzly Valley Reservoir and utilized for recreational purposes at that reservoir, for stream maintenance in the channels of Big Grizzly Creek and the Middle Fork of the Feather River between Grizzly Valley Reservoir and Nelson Point Reservoir sites, for municipal purposes at

Portola and urban areas in the Middle Fork service area, and for irrigation purposes in Mohawk and Long Valleys.

Application No. 16951 proposes the appropriation of 18,200 acre-feet per annum from Indian Creek. Water sought under this application would be stored in Antelope Valley Reservoir and utilized for recreational purposes at that reservoir and for stream maintenance along the reach of Indian Creek below Antelope Valley Reservoir to Indian Valley.

Applications Nos. 16952 and 18844 are for appropriation of 30,000 and 20,000 acre-feet per annum, respectively, from Little Last Chance Creek. Water sought under these applications will be stored in Frenchman Reservoir and utilized for irrigation and other purposes in Sierra Valley. These applications were assigned, upon the recommendation of the California Water Commission, to the department as the constructor of the project on July 30, 1959. These applications were subsequently completed, advertised, and protests were received from the United States Bureau of Reclamation and the Pacific Gas and Electric Company. Negotiations are now in progress concerning these protests.

Application No. 16953 proposes the appropriation of 14,300 acre-feet per annum from Last Chance Creek. Water sought under this application would be stored in Dixie Refuge Reservoir and utilized for recreational purposes at that reservoir and for stream flow maintenance of Last Chance Creek from Dixie Refuge Dam to Indian Valley.

Application No. 16954 proposes the appropriation of 8,400 acre-feet per annum from Red Clover Creek. Water sought under this application would be stored in Abbey Bridge Reservoir, and utilized for recreational purposes at that reservoir and stream maintenance of Red Clover Creek below Dixie Refuge Reservoir to Indian Valley.

On February 26, 1960, the department requested the California Water Commission to assign to it Applications Nos. 5629, 5630, 14443, 14444, 17512, 17514, 17515, and a portion of Application No. 14445. These applications are necessary for the completion of the Feather River and Delta Diversion Projects as authorized by Chapter 1762, Statutes of 1959 (Burns-Porter Act). At the same time, the department proposed amendments for the consideration of the commission to bring the applications into line with present plans for the projects.

On June 2 and July 1, 1960, the commission held hearings on the request of the department. As a result of comments received at these hearings, the applications were amended to include the Airpoint Reservoir in Santa Clara County. The commission held a further hearing on September 16. A decision on the request is awaiting action of the commission (October 1, 1960).

The department has consistently followed the policy that the counties of origin should be allowed to use such water as may be necessary for their future development. The department has recommended that the assignment of these applications be made subject to the following general reservation for the counties of origin:

> "Subject to the prior rights of any county in which the water sought to be appropriated originates to use such water as may be necessary for the development of the county, as provided in Section 10505 of the Water Code of California."

Other Downstream Water Rights

In addition to applications held by the State of California for diversion from the Sacramento-San Joaquin River Delta for the Feather River and Delta Diversion Projects, there are many other rights to water originating in the Feather River. These include rights to divert water from the Feather River below Oroville, from the Sacramento River below its confluence with the Feather River, and from the Delta. They consist of riparian rights, appropriative rights initiated both before and after the Water Commission Act, and other rights. They also include five state applications. Applications Nos. 9363, 9364, 9366, 9367, and 9368 were filed by the State on August 2, 1938, and were assigned to the United States Bureau of Reclamation for the operation of the Federal Central Valley Project. These applications propose the appropriation of water from the Sacramento River and in the Delta.

Application No. 9364, which includes a direct diversion of 9,000 second-feet from the Sacramento River and the Delta, was assigned to the United States on September 3, 1938. The assignment contained a reservation of a specific quantity of water for counties of origin above Shasta Dam, but no reservation was included that would benefit the counties of origin in the Feather River watershed.

Applications Nos. 9363, 9366, 9367, and 9368 were assigned to the United States on March 26, 1952. The assignments were made subject to a general reservation for the counties of origin as follows:

> "Subject, however, in conformity with Section 10505 of the Water Code of the State of California, to any and all rights of any county in which the water sought to be appropriated originates to the extent that any such water may be necessary for the development of such county".

This reservation should fully protect the counties of the Upper Feather River Basin as to water originating within their boundaries from deprivation of such water by export under these four applications.

As mentioned previously, there are many downstream water rights not based on state applications. In the Delta, these include a number of applications by public agencies for the export of large quantities of water. Since the County of Origin Law applies only to state applications, the counties of origin are not protected by it in relation to other downstream applications. Likewise, little protection is afforded to them by the Watershed Protection Act, since these applications are not, in most cases, for projects that are part of the Central Valley Project.

Upper Basin Water Rights

Table 6 lists all applications in the Upper Feather River Basin on file with the State Water Rights Board in excess of three second-feet of direct diversion and 200 acre-feet of storage. The table includes both approved and pending applications and also applications filed by the State of California above the Oroville dam site, which were described in detail earlier in this chapter. The applications of Richvale Irrigation District and R. P. Wilson are discussed in the following paragraphs.

Richvale Irrigation District

Application No. 13681 was filed by Richvale Irrigation District on April 10, 1950, and seeks to appropriate 132,000 acre-feet per annum from the Middle Fork of the Feather River, of which 72,000 and 60,000 acre-feet are to be impounded in Clio and Nelson Point Reservoirs, respectively, and then diverted through downstream power plants.

TABLE 6

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER
STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water		Purpose	Status
				In second-feet	In acre-feet		
1651	2-2-20	Oroville-Wyandotte Irrigation District	South Fork Feather River	200	109,012	Irrigation	Permit
1739	3-25-20	Table Mountain and Thermalito Irrigation District	East Branch at Feather River (Lake Wilenor)		8,200	Irrigation	License
2142	12-17-20	Oroville-Wyandotte Irrigation District	Lost Creek		45,000	Irrigation	Permit
2186	2-1-21	Pacific Gas and Electric Company	North Fork Feather River (Bucks Lake)		70,000	Irrigation	Permit
2195	2-10-21	Pacific Gas and Electric Company	North Fork Feather River (Bucks Lake)		55,000	Power	License
2755	2-9-22	Pacific Gas and Electric Company	North Fork Feather River		5,060	Power	License
2778	3-6-22	Oroville-Wyandotte Irrigation District	Lost Creek	50	25,000	Irrigation	Permit
2979	8-12-22	Oroville-Wyandotte Irrigation District	Lost Creek	185		Irrigation	Permit

TABLE 6 (continued)

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water: In second-feet	Amount of water: In acre-feet	Purpose	Status
3040	9-16-22	Table Mountain and Thermalito Irrigation District	East Branch of Feather River (Lake Wilenor)		8,200	Power	License
4491	3-5-25	Pacific Gas and Electric Company	Bucks Creek Grizzly Creek	175		Power	License
4598	5-22-25	Pacific Gas and Electric Company	Grizzly Creek	105		Power	License
4871	12-21-25	Pacific Gas and Electric Company	Grizzly Creek	20.		Power	License
6204	2-27-29	Paradise Irrigation District	North Fork Feather River (Long Gulch Reservoir)		5,000	Irrigation	Permit
6241	4-8-29	Pacific Gas and Electric Company	14 streams tributary to North Fork Feather River	65		Power	License
7003	7-10-31	Robert and Margaret Holt and Marion Higgins Anna W. Shotte and Marion T. Higgins	Black Hawk Creek	4.6		Mining and Domestic	License
8495	11-14-35	Placerville Lumber Company	Graeagle Creek	13.75	1,500	Power	License

TABLE 6 (continued)

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water: In second-feet	Amount of water: In acre-feet	Purpose	Status
8496	11-14-35	Placerville Lumber Company	Graeagle Creek	4		Domestic and Industrial	License
9800	1-9-40	Pacific Gas and Electric Company	North Fork Feather River (Belden, Cresta, Poe Dams)	3,500		Power	Permit
13676	4-7-50	Oroville-Wyandotte Irrigation District and Yuba County Water District	South Fork Feather River (Little Grass Valley Reservoir)	200	77,300	Power	Permit
			Lost Creek (Sly Creek Reservoir)	100	40,000		
13681	4-10-50	Richvale Irrigation District	Middle Fork Feather River Frazier Creek Graeagle Creek (Clio and Nelson Point Reservoirs)		132,000	Irrigation and Domestic	Application
13682	4-10-50	Richvale Irrigation District	Middle Fork Feather River	300		Power	Application
13694	4-17-50	National Youth Foundation	Indian Creek East Branch North Fork Feather River Spanish Creek	800	12,000	Power	Application

TABLE 6 (continued)

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER
STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water: In second-feet	Amount of water: In acre-feet	Purpose	Status
13744	5-18-50	National Youth Foundation	Lights Creek Moonlight Creek	100	25,000	Power	Application
14112	12-28-50	Oroville-Wyandotte Irrigation District and Yuba County Water District	South Fork Feather River	150		Power	Permit
			Lost Creek	250			
14113	12-28-50	Oroville-Wyandotte Irrigation District and Yuba County Water District	South Fork Feather River (Little Grass Valley Reservoir)		77,300	Irrigation	Permit
			Lost Creek (Sly Creek Reservoir)		40,000		
14185	3-9-51	Paradise Irrigation District	West Branch North Fork Feather River (Clear Creek Reservoir)		5,000	Irrigation and Domestic	Permit
14919	7-21-52	Richvale Irrigation District	Middle Fork Feather River (Clio and Nelson Point Reservoirs)	1,300	381,000	Irrigation and Domestic	Application
14920	7-21-52	Richvale Irrigation District	Middle Fork Feather River (Clio and Nelson Point Reservoirs)	1,300	381,000	Power	Application

TABLE 6 (continued)

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER
STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water: In second-feet	Amount of water: In acre-feet	Purpose	Status
15551	9-25-53	Richvale Irrigation District	Big Grizzly Creek (Grizzly Valley Reservoir)		40,000	Irrigation	Application
			Frazier Creek (Gold Lake)		16,000		
15552	9-25-53	Richvale Irrigation District	Big Grizzly Creek (Grizzly Valley Reservoir)		40,000	Power	Application
			Frazier Creek (Gold Lake)		16,000		
16315	4-15-55	City of Oroville	Lost Creek	30	15,000	Municipal	Incomplete
			South Fork Feather River	30			
16533	8-19-55	City of Portola	Freeman Creek	1	1,270	Municipal	Application
			Cow Creek				
16950	3-20-56	State Department of Water Resources	Big Grizzly Creek (Grizzly Valley Reservoir		49,000	Recreation, Municipal and Irrigation	Application

TABLE 6 (continued)

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER
STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water		Purpose	Status
				In second-feet	In acre-feet		
16951	3-20-56	State Department of Water Resources	Indian Creek (Antelope Valley Reservoir)		18,200	Recreation and Stream flow maintenance	Application
16952	3-20-56	State Department of Water Resources	Little Last Chance Creek (Frenchman Reservoir)		30,000	Irrigation	Application
16953	3-20-56	State Department of Water Resources	Last Chance Creek (Dixie Refuge Reservoir)		14,300	Recreation and Stream flow maintenance	Application
16954	3-20-56	State Department of Water Resources	Red Clover Creek (Abbey Bridge Reservoir)		8,400	Recreation and Stream flow maintenance	Application

TABLE 6 (continued)

MAJOR APPLICATIONS TO APPROPRIATE WATER ON FEATHER RIVER
STREAM SYSTEM ABOVE OROVILLE DAM SITE

(Applications in excess of 3 second-feet constant diversion or 200 acre-feet of storage)

Application	Date filed	Name of applicant	Source of water	Amount of water		Purpose	Status
				In second-feet	In acre-feet		
17687	6-28-57	R. P. Wilson	Davis Creek tributary to Indian Creek	20	3,000	Power	Application
18410	11-13-58	Yuba County Water District	Fall River		20,000	Irrigation	Incomplete
			Rock Creek (New York Flat Reservoir)		3,000	Domestic	
18567	3-4-59	Robert P. Wilson	Indian Creek	300	47,000	Power and Recreational	Incomplete
18844	7-6-59	State Department of Water Resources	Little Last Chance Creek (Frenchman Reservoir)		20,000	Domestic, Irrigation, Stock-watering, and Recreational	Application

Application No. 13682 was filed by Richvale Irrigation District on April 10, 1950, and seeks to appropriate 300 second-feet from the Middle Fork of the Feather River for power purposes. Under this application, water would be stored behind Clio Dam and diverted through downstream power plants.

Applications Nos. 14919 and 14920 were filed by Richvale Irrigation District on July 21, 1952, and seek to appropriate a maximum of 1,300 second-feet direct diversion at Sutter Butte Dam and a total of 381,000 acre-feet per annum by storage from the Middle Fork of the Feather River for irrigation and power purposes, respectively. The storage will be in various reservoirs throughout the system.

Applications Nos. 15551 and 15552, filed by Richvale Irrigation District on September 25, 1953, are for irrigation and power purposes, respectively. Each application seeks to appropriate 40,000 acre-feet per annum from Big Grizzly Creek for storage in Grizzly Valley Reservoir and 16,000 acre-feet per annum from Frazier Creek for storage in Gold Lake. The general plan under these two applications is to release the stored water into the natural channels of Grizzly Creek and Frazier Creek for storage in Clio and Nelson Point Reservoirs. From these reservoirs, the water would be diverted through the chain of power plants contemplated under the project, thence down the Feather River to Sutter Butte diversion dam, where the water would be diverted for irrigation purposes within the district.

All of the applications of the Richvale Irrigation District have been completed and advertised. Numerous protests have been filed, and the first day of hearing was conducted by the State Water Rights Board on September 22, 1959. This hearing was then continued for an indefinite period to allow time for the completion of studies and investigations then being conducted by several of the interested parties. Recently, the Richvale Irrigation District has petitioned the State Water Rights Board for permission to change the place of use under its applications. The proposed place of use would embrace land within the Richvale Irrigation District, the Biggs-West Gridley Water District, the Butte Water District, and the Sutter Extension Water District.

The Richvale Irrigation District has petitioned the California Water Commission for a release from priority of Applications Nos. 5629, 5630, 14443, 14444, and 14445 in favor of its applications.

On June 3, July 7, and September 15 the commission held hearings on the petition. Considerable testimony was received from the Richvale Irrigation District and Plumas County. A decision on the petition is awaiting the action of the commission (October 1, 1960). Details of the project of the Richvale Irrigation District are included in Chapter VI.

A comparison of the applications filed by the State and the Richvale Irrigation District shows that both are proposing appropriations at Grizzly Valley Reservoir. Under Application No. 16950, filed by the State, the water would be used primarily for irrigation within Sierra Valley. Under Applications Nos. 15551 and 15552, the Richvale Irrigation District seeks to appropriate water impounded in Grizzly Valley Reservoir for the generation of hydroelectric energy at various power plants along the Middle Fork of the Feather River and for irrigation of land within the four districts comprising the proposed place of use.

<u>R. P. Wilson</u>

Mr. R. P. Wilson has four applications pending before the State Water Rights Board covering projects on tributaries of the North Fork of the Feather River. At one time, Mr. Wilson had other applications for a comprehensive development on the Middle Fork of the Feather River, which was similar to that proposed by the Richvale Irrigation District. However, these applications were not completed and were cancelled. The active applications are Nos. 13694 and 13744, which are currently in the name of the National Youth Foundation of which Mr. Wilson is President, and Applications Nos. 17687 and 18567, which are in Mr. Wilson's name. Numerous protests have been received against Applications Nos. 13694, 13744 and 17687. The protests were heard before the State Water Rights Board on February 10, 1960, and are currently under consideration by that body. Application No. 18567 is incomplete.

Approved Applications

Water rights permits or licenses have been issued to the Pacific Gas and Electric Company, Paradise Irrigation District, Table Mountain and Thermalito Irrigation Districts, Graeagle Lumber Company (now Placerville Lumber Company), Anna W. Shotte and Marion T. Higgins, and jointly to the Oroville-Wyandotte Irrigation District and the Yuba County Water District. The power development of the Pacific Gas and Electric Company on the North Fork of the Feather River is nearing completion, and Mosquito Junction Dam of the Paradise Irrigation District has been built. Further work is required by the district to put the full amount of water to beneficial use.

The project planned on the South Fork of the Feather River by the Oroville-Wyandotte Irrigation District and the Yuba County Water District is described in Chapter VI. On December 12, 1958, the State executed a release from priority of State Applications Nos. 5629 through 5632, in favor of Applications Nos. 13676, 13956, 13957, 14112, and 14113, held jointly by these districts. The release included a reservation for reasonable domestic use for that portion of the watershed of the South Fork of the Feather River located in Plumas County.

The South Fork Project, to be constructed by the Oroville-Wyandotte Irrigation District under the applications held jointly by that district and the Yuba County Water District, will also divert water from Slate Creek (tributary to the Yuba River) into the South Fork Project system. When constructed, the South Fork Project will operate principally for generation of power until the bond issue sold to construct the project has been repaid, after which it is planned to operate it mainly for the irrigation of land in both districts. Many of the applications held exclusively by the Oroville-Wyandotte Irrigation District, shown in Table 6, duplicate quantities of water named in the joint applications.

Adjudications

Water rights have been determined on a comprehensive basis by adjudication proceedings on the headwaters of the Middle Fork of the Feather River in Sierra Valley and on the headwaters of the North Fork in Indian Valley and are set forth in judgments and decrees of the Superior Court of Plumas County, No. 3095, dated January 19, 1940, and No. 4185, dated December 19, 1950, respectively.

Land irrigated under rights established by the Sierra Valley decree totals about 39,000 acres and by the Indian Valley decree, about 14,000 acres. Both of these areas have been formed into watermaster service areas, and water is distributed in accordance with the provisions of the decrees during each irrigation season by a state watermaster.

Federal Power Commission Preliminary Permits

The Richvale Irrigation District, the Pacific Gas and Electric Company, and R. P. Wilson all applied for Federal Power Commission preliminary power permits in 1953 for their respective power development proposals. The Richvale Irrigation District application is designated as Project No. 2134. The Pacific Gas and Electric Company application, designated as Project No. 2136, was similar to the proposal of the Richvale Irrigation District. R. P. Wilson filed three applications for preliminary power permits--Projects Nos. 2124, 2125, and 2126.

On February 11, 1957, the Federal Power Commission issued an order granting a preliminary permit to the Richvale Irrigation District for the purpose of maintaining the priority of its application for a license for Project No. 2134. This order also denied permits on Project No. 2124 of R. P. Wilson, and on Project No. 2136 of the Pacific Gas and Electric Company. These three projects propose development on the same reach of stream, and it would not be possible to construct more than one project. The permit was issued to the Richvale Irrigation District pursuant to Section 7(a) of the Federal Power Commission Act /41 Stat. 1063, 1067 (1920), as amended, 16 U.S.C. sec. 800 (a) (1958 ed.)/, which requires the commission to give preference to applications by states or districts over others, provided the plans of the state or district are equally well adapted to conserve in the public interest the water resources of the region. The district has now filed an application with the commission for a license for Project No. 2134, and petitions to intervene by the State, on behalf of the Department of Water Resources and the Department of Fish and Game, and by Plumas County have been granted.

On June 17, 1957, the commission issued an order granting preliminary permits to R. P. Wilson (National Youth Foundation) for Projects Nos. 2125 and

2126 for power development of the North Fork of the Feather River and tributaries, which developments are not in conflict with the Richvale Irrigation District project on the Middle Fork of the Feather River. The Federal Power Commission on August 10, 1960, issued a notice of application for license on Project Nos. 2125 and 2126 by the above applicant. These applications are pending before the commission (October 1, 1960). A license must be obtained before construction can begin.

CHAPTER IV. WATER SUPPLY

The sources of water supply to lands of the Upper Feather River Basin are direct precipitation on the overlying lands, and surface and subsurface flows. Melting snow produces the major portion of the seasonal runoff which occurs in the late spring and early summer months. By late summer, the streams of the basin have reached their seasonal minimum and are sustained only by springs and areas of seepage. The resulting seasonal runoff pattern is one of concentrated spring floods and low summer flows. In addition to these intraseasonal cyclic fluctuations, runoff varies from season to season depending upon the amount of seasonal precipitation. Although some water is imported and exported across the basin boundaries, the amount is negligible in relation to the total water supply. Direct diversion of unregulated stream flows is the chief source of water for irrigation and domestic purposes. Ground water exists in the alluvial basins, and in many places water supplies are obtained from individual wells for domestic, stockwatering, and irrigation purposes.

In this chapter, the water supply of the Upper Feather River Basin is considered and evaluated under the general headings, "Precipitation", "Surface Water", "Ground Water", and "Water Quality".

Precipitation

The Upper Feather River Basin lies within the area traversed by the southern portion of storms which sweep inland from the north Pacific Ocean during winter and spring months. The precipitation from these storms is moderately heavy and, except for the eastern portion of the basin, generally increases with land elevation. Pronounced and abrupt changes in altitude and topography have marked effects on the amount of precipitation and on its occurrence as rain or snow in the basin.

Precipitation Stations and Records

There are 35 known precipitation stations in or adjacent to the Upper Feather River Basin with continuous records of 12 years duration or longer. However, these stations are not well distributed areally in that there are no stations located in considerable portions of the upper drainage basins of the North and Middle Forks of the Feather River. About 53 percent of the basin is above an elevation of 5,000 feet and only five precipitation stations are at or above this elevation, the highest being at 5,200 feet.

There are 24 snow courses located in or adjacent to the Upper Feather River Basin which are measured and maintained as a part of the California Cooperative Snow Surveys program. All except one of these courses are located at or above an elevation of 5,000 feet, eight are above 6,000 feet, and one is above 8,000 feet. Since the highest precipitation gage is located at an elevation of 5,200 feet, measurements at these snow courses are the only records of precipitation available for approximately one-half of the area.

Records of precipitation utilized in this investigation have been published in bulletins of the United States Weather Bureau and the Department of Water Resources. Locations of the precipitation stations and snow courses are shown on Plate 3, "Lines of Equal Mean Seasonal Precipitation, 1905-06 through 1954-55". Map reference numbers for precipitation stations shown on this plate designate the major drainage basin in which the stations are located and the United States Weather Bureau identification number. Also, the reference numbers for snow survey courses are those assigned by the Department of Water Resources.

The known precipitation stations with continuous records of 12 years duration or more are listed in Table 7, together with their elevations, periods and sources of record, and values of mean, maximum, and minimum seasonal precipitation. In those instances where it was necessary, precipitation records were extended to cover the 50-year mean period by direct correlation with records of nearby stations covering the longer period. Snow survey courses are listed in Table 8, together with elevations, periods of records and values of average, maximum and minimum depth of water content of the snow on April 1.

In plotting the lines of equal mean seasonal precipitation, or isohyets, as shown on Plate 3, the estimated 50-year mean seasonal depths of precipitation at stations with 12 years or more of record in or adjacent to the area, were plotted on a map at a scale of 1:250,000. The isohyets were then drawn taking into consideration these precipitation data, as well as local variations in topography, data obtained from snow survey courses, short-period precipitation records and isohyetal maps prepared by other agencies. In utilizing the data presented on Plate 3 for hydrologic studies, the isohyets were taken only as an indication of the general precipitation trend. The relatively small number of precipitation stations, particularly throughout upper portions of the basin, limits the usefulness of the isohyets.

TABLE 7

PRECIPITATION DATA AND STATIONS IN OR
ADJACENT TO THE UPPER FEATHER RIVER BASIN

(With continuous records of 12 years or longer)

Reference number	Station	County	Latitude and longitude	Elevation in feet	Period of record	Source of record[1]	Seasonal depth of precipitation: Mean 1905-1955, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
A5-4274	Inskip Inn	Butte	40°00' 121°32'	4,818	1907-08[2] 1953-54	USWB	76.20[3]	1937-38 1923-24	124.11 32.36
A5-9540	West Branch	Butte	39°56' 121°32'	3,216	1907-08 1951-52	USWB	70.50[3]	1908-09 1923-24	115.35 33.13
A4-2402	De Sabla	Butte	39°52' 121°37'	2,713	1904-05 1958-59	USWB	60.98[3]	1940-41 1923-24	99.06 26.84
A5-8544	Stirling City R.S.	Butte	39°55' 121°32'	3,525	1903-04[2] 1958-59	USWB	63.62[3]	1906-07 1917-18	125.20 36.76
A4-1624	Centerville P.H.	Butte	39°47' 121°40'	520	1914-15 1958-59	USWB	42.99[3]	1940-41 1923-24	70.79 20.54
A5-4812	Las Plumas	Butte	39°41' 121°29'	506	1914-15 1958-59	USWB	48.62[3]	1940-41 1922-24	77.50 20.72
A5-4273	Intake	Butte	39°43' 121°28'	920	1921-22 1937-38	PG&E	48.19[3]	1937-38 1923-24	74.33 24.15
A5-1130	Brush Creek R.S.	Butte	39°41' 121°20'	3,500	1903-04[2] 1958-59	USWB	68.93[3]	1937-38 1911-12	109.06 32.32
A5-4722	Lake Wilenor	Butte	39°46' 121°32'	1,970	1931-32 1958-59	T&TMID	51.34[3]	1940-41 1938-39	83.85 28.32

TABLE 7 (continued)

PRECIPITATION DATA AND STATIONS IN OR
ADJACENT TO THE UPPER FEATHER RIVER BASIN

(With continuous records of 12 years or longer)

Reference number	Station	County	Latitude and longitude	Elevation in feet	Period of record	Source[1/] of record	Seasonal depth of precipitation: Mean 1905-1955, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
A0-6525	Oroville Bridge	Butte	39°31' 121°34'	220	1908-09 1958-59	USWB	26.95[3/]	1951-52 1911-12	43.94 14.31
A0-6521	Oroville 1WSW	Butte	39°30' 121°34'	160	1884-85 1958-59	USWB	27.07	1889-90 1930-31	49.64 14.71
A0-6528	Oroville R.S.	Butte	39°32' 121°34'	265	1940-41 1958-59	USWB	25.26[3/]	1940-41 1945-46	40.72 19.30
A5-3127	Forbestown	Butte	39°32' 121°17'	2,800	1920-21 1937-38	Private	63.84[3/]	1937-38 1923-24	105.35 29.67
A5-6523	Oroville 7SE	Butte	39°26' 121°29'	530	1920-21 1958-59	USWB	29.10[3/]	1940-41 1923-24	44.08 15.79
G4-8701	Susanville	Lassen	40°25' 120°39'	4,195	1885-86[2/] 1958-59	USWB	12.87	1889-90 1949-50	36.26 8.22
G6-2504	Doyle Dixon	Lassen	40°02' 120°06'	4,266	1923-24 1958-59	DWR	9.44	1937-38 1954-55	17.43 4.91
G6-5623	Milford Laufman R. S.	Lassen	40°08' 120°21'	4,860	1940-41 1957-58	USWB	18.20	1955-56 1954-55	39.32 12.42
A5-1700	Chester	Plumas	40°18' 121°13'	4,530	1910-11 1958-59	USWB	30.09[3/]	1955-56 1923-24	50.49 12.98

TABLE 7 (continued)

PRECIPITATION DATA AND STATIONS IN OR
ADJACENT TO THE UPPER FEATHER RIVER BASIN

(With continuous records of 12 years or longer)

Reference number	Station	County	Latitude and longitude	Elevation in feet	Period of record	Source[1/] of record	Seasonal depth of precipitation: Mean 1905-1955, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
A5-1497	Canyon Dam	Plumas	40°10' 121°05'	4,555	1907-08 1955-59	USWB	36.77[3/]	1937-38 1923-24	64.59 14.52
A5-0128	Almanor	Plumas	40°13' 121°10'	4,600	1923-24[2/] 1958-59	PG&E	38.54[3/]	1955-56 1923-24	60.73 14.24
A5-1526	Caribou	Plumas	40°05' 121°09'	3,000	1922-23 1958-59	PG&E	39.17[3/]	1937-38 1923-24	66.84 14.55
A5-3621	Greenville R.S.	Plumas	40°08' 121°56'	3,560	1894-95 1958-59	USWB	35.75	1906-07 1911-12	67.34 22.61
A5-9295	Veramont	Plumas	40°06' 121°50'	3,500	1920-21 1951-52	PG&E	31.81[3/]	1937-38 1923-24	52.43 14.54
A5-1153	Bucks Creek P.H.	Plumas	39°54' 121°20'	1,760	1929-30 1958-59	USWB	63.32[3/]	1937-38 1938-39	103.02 36.63
A5-1161	Bucks Lake	Plumas	39°54' 121°14'	5,200	1930-31 1958-59	USWB	68.72[3/]	1951-52 1930-31	108.84 28.36
A5-2689	Edmonton	Plumas	39°54' 121°06'	4,750	1877-78 1904-05	USWB	74.12[3/]	1889-90 1897-98	139.15 42.04
A5-2998	Feather River (Calif. For.)	Plumas	39°58' 120°56'	3,480	1912-13 1951-52	F&RESB	31.10[3/]	1913-14 1930-31	50.96 15.76

TABLE 7 (continued)

PRECIPITATION DATA AND STATIONS IN OR
ADJACENT TO THE UPPER FEATHER RIVER BASIN

(With continuous records of 12 years or longer)

Reference number	Station	County	Latitude and longitude	Elevation in feet	Period of record	Source[1] of record	Seasonal depth of precipitation: Mean 1905-1955, in inches	Maximum and minimum: Season	Inches
A5-7195	Quincy R.S.	Plumas	39°56' 120°57'	3,409	1895-96 1958-59	USWB	39.05	1906-07 1911-12	73.22 20.25
A5-4773	La Porte	Plumas	39°41' 120°58'	4,975	1894-95 1932-33	USWB	70.65[3]	1910-11 1923-24	165.05 29.52
A5-7085	Portola	Plumas	39°48' 120°28'	4,838	1915-16 1955-56	USWB	18.14[3]	1951-52 1923-24	36.10 6.17
A5-9351	Vinton	Plumas	39°49' 120°11'	4,945	1941-42 1958-59	USWB	10.63[3]	1950-51 1954-55	19.31 7.54
A6-2500	Downieville R.S.	Sierra	39°34' 120°50'	2,895	1908-09 1958-59	USWB	60.84[3]	1955-56 1923-24	89.89 25.78
A5-8218	Sierraville R.S.	Sierra	39°35' 120°22'	4,975	1909-10 1958-59	USWB	24.22[3]	1913-14 1923-24	43.80 8.23
A4-5679	Mineral	Tehama	40°21' 121°36'	4,850	1909-10 1958-59	USWB	49.45	1937-38 1938-39	84.57 23.75

1/ USWB - United States Weather Bureau
PG&E - Pacific Gas and Electric Company
SFD - California State Division of Forestry
F&RESB - Forest and Range Experiment Station, Berkeley
T&TMID - Thermalito and Table Mountain Irrigation District

2/ Broken record

3/ Partially estimated

TABLE 8

SNOW SURVEY DATA AND COURSES IN OR ADJACENT
TO THE UPPER FEATHER RIVER BASIN

California number	Course	County	Latitude and longitude	Elevation, in feet	Period of record	Depth of water content of snow on April 1: Average 1930-1959, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
336	Upper Lassen Peak	Shasta	40°28.4' 121°30.4'	8,400	1931 1959	79.0*	1938 1939	160.2 41.4
48	Mount Dyer No. 1	Lassen	40°14.6' 121°01.8'	7,400	1930 1959	24.2	1938 1934	52.4 2.2
74	Yuba Pass	Sierra	39°37.0' 120°39.5'	6,700	1937 1959	31.8*	1952 1959	74.7 16.7
279	Eureka Bowl	Plumas	39°45.3' 120°43.2'	6,800	1948 1959	41.9*	1958 1948	77.1 24.1
50	Fredonyer Pass No. 1	Lassen	40°21.0' 120°51.5'	5,600	1926 1959	9.7	1938 1931,47, 50,57	30.1 0.0
51	Harkness Flat	Plumas	40°25.5' 121°16.0'	6,400	1926 1959	28.4	1952 1934	59.1 10.7
52	Eureka Lake	Plumas	39°45.7' 120°42.8'	6,200	1939 1959	32.3*	1952 1947	72.9 14.8
290	Mount Dyer No. 2	Lassen	40°15.5' 121°02.2'	6,200	1952 1959	16.6*	1952 1957	35.5 6.9
49	Letterbox	Plumas	39°51.4' 121°15.8'	5,600	1940 1959	46.9*	1952 1947	106.5 19.7

TABLE 8 (continued)

SNOW SURVEY DATA AND COURSES IN OR ADJACENT TO THE UPPER FEATHER RIVER BASIN

California number	Course	County	Latitude and longitude	Elevation, in feet	Period of record	Depth of water content of snow on April 1: Average 1930-1959, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
55	Mount Stover	Plumas	40°18.5' 121°19.0'	5,600	1926 1959	16.6	1952 1931	43.2 0.2
291	Fredonyer Pass No. 2	Lassen	40°22.0' 120°52.6'	5,200	1952 1959	4.0*	1952 1953,54, 55,57,59	17.4 0.0
56	Browns Camp	Plumas	39°54.0' 121°14.5'	5,400	1937 1959	22.1	1952 1947	63.6 0.0
277	Gibsonville	Sierra	39°43.5' 120°56.2'	5,400	1950 1959	34.4*	1952 1957	77.6 13.3
57	Haskins Flat	Plumas	39°52.0' 121°12.0'	5,200	1930 1959	29.8	1952 1947	79.7 0.0
58	Feather River	Plumas	40°22.5' 121°25.0'	5,500	1926 1959	22.8	1952 1931	50.0 4.1
59	Warner Creek	Plumas	40°23.5' 121°18.0'	5,000	1926 1959	16.1	1952 1931	39.2 0.0
60	Humbug Summit	Plumas	40°10.5' 121°18.5'	5,000	1926 1959	12.4	1952 1940	34.4 0.0
61	Chester Flat	Plumas	40°17.5' 121°14.0'	4,600	1926 1959	7.3	1952 1931,34,46,47, 53,55,57,& 59	29.1 0.0

TABLE 8 (continued)

SNOW SURVEY DATA AND COURSES IN OR ADJACENT
TO THE UPPER FEATHER RIVER BASIN

California number	Course	County	Latitude and longitude	Elevation, in feet	Period of record	Depth of water content of snow on April 1: Average 1930-1959, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
280	Roland Creek	Plumas	40°00.5' 120°17.8'	6,850	1950 1959	18.1*	1952 1951	43.9 10.8
75	Church Meadows	Plumas	39°40.9' 120°37.4'	6,700	1931 1959	30.4*	1952 1931	57.3 17.6
45	Lake Nokopen (Silver Lake)	Lassen	40°29.8' 121°09.2'	6,450	1940 1959	27.7*	1952 1947	56.4 14.0
46	Norvell Flat	Lassen	40°28.9' 121°00.4'	5,700	1940 1959	16.5*	1952 1947	40.6 0.0
54	Mill Creek Flat	Plumas	39°56.0' 121°11.5'	5,800	1930 1959	38.8	1952 1934	86.6 7.0
53	Three Lakes	Plumas	39°58.0' 121°13.0'	6,100	1930 1959	39.2	1952 1931	93.7 3.7
82	Sardine Flat	Sierra	39°37.3' 120°36.7'	5,700	1937 1959	18.0*	1952 1947	48.7 0.0

* Partially estimated

Precipitation Characteristics

Precipitation on the Upper Feather River Basin varies between wide limits from season to season and generally increases abruptly with increase in elevation. Due to the orographic effect of the Sierra Nevada, however, the eastern half of the upper basin, although higher in elevation, receives less precipitation than the western half. Winter storms deposit relatively light precipitation in crossing the floor of the Sacramento Valley but drop moisture at increasing rates as these storms are lifted by the Sierra Nevada. A maximum rate of precipitation is reached along the intermittently defined first crest of the Sierra. Precipitation then decreases rapidly until the effects of local barriers such as Grizzly Mountain, Dixie Mountain and Kettle Peak reverse the trend slightly. There is a sharp contrast in the amount of precipitation between the relatively dry easterly watersheds of Sierra and Red Clover Valleys and those of the highly water-productive downstream tributary areas.

Mean seasonal depth of precipitation reaches a maximum along the ridge southwest of Bucks Lake, being in excess of 80 inches. Minimum mean seasonal depth of precipitation is less than 10 inches and occurs in Sierra Valley. The maximum recorded seasonal depth of precipitation in the Upper Feather River Basin occurred at La Porte in the season of 1910-11 and was 165.05 inches. The minimum recorded seasonal precipitation occurred at Portola in the season of 1923-24 and was 6.17 inches. The maximum water content of any snow pack recorded in California occurred within the Upper Feather River Basin at the Upper Lassen Peak snow course on April 1, 1938, when a water content of 160.2 inches was measured.

The average monthly distribution of precipitation at the United States Weather Bureau stations at Bucks Lake and Quincy is shown in Table 9. Over 75 percent of the seasonal precipitation at each of these stations occurs during the 5-month period from November 1 to March 31. The variation in precipitation

TABLE 9

MONTHLY DISTRIBUTION OF AVERAGE
SEASONAL PRECIPITATION AT BUCKS LAKE AND QUINCY
1930-31 THROUGH 1955-56

Month	Bucks Lake		Quincy	
	In inches of depth	In percent of seasonal total	In inches of depth	In percent of seasonal total
July	.12	.17	.10	.25
August	.12	.17	.11	.27
September	.51	.73	.40	1.00
October	3.95	5.69	2.43	6.09
November	7.25	10.45	4.49	11.25
December	13.27	19.12	7.30	18.29
January	13.45	19.39	7.18	17.99
February	11.15	16.07	6.70	16.78
March	9.60	13.83	5.20	13.03
April	5.39	7.77	3.29	8.24
May	3.30	4.76	1.94	4.86
June	1.28	1.85	.78	1.95
TOTALS	69.39	100.00	39.92	100.00

from season to season is shown in Table 10, which lists the historical seasonal precipitation at De Sabla, Quincy and Portola. Data for the foregoing stations are considered representative of precipitation characteristics in the Upper Feather River Basin.

Surface Water

Runoff from rainfall and snowmelt constitutes by far the most important source of water supply available for development in the Upper Feather River Basin. Runoff from the basin is also extensively used for irrigation purposes in the Sacramento Valley. A substantial portion of this runoff, however, is unregulated and undeveloped and is a potential source of water to meet future requirements in the basin as well as in water-deficient areas in other parts of California.

Stream Gaging Stations and Records

Available records of runoff of the principal streams of the Upper Feather River Basin were sufficient in number, length and reliability to form the basis of estimates of runoff required for hydrologic studies for the investigation. Ten stream gaging stations were established by the (then) Division of Water Resources in 1954 for the purpose of supplying additional hydrographic data. Other measurements were made by the department's Watermaster Service but these were limited to those obtained during the irrigation season.

In Table 11 there are presented those stream gaging stations pertinent to the hydrography of the Upper Feather River Basin, together with their reference numbers, drainage areas, and periods and sources of records. Locations of the stream gaging stations are shown on Plate 3.

The reference numbers for all stations listed in Table 11 are those assigned by the Department of Water Resources. The numbers designate the major

TABLE 10

RECORDED SEASONAL PRECIPITATION
AT SELECTED STATIONS
IN THE UPPER FEATHER RIVER BASIN

(In inches of depth)

Season	De Sabla	Quincy	Portola	Season	De Sabla	Quincy	Portola
1911-1912	43.95	20.25		1935-1936	65.87	38.26	15.28
13	59.75	26.01		37	50.86	29.66	17.19
14	97.88	51.45		38	91.31	65.58	29.44
15	86.33	24.21		39	33.99	21.42	11.43
				40	81.55	52.51	27.02
1915-1916	70.96	47.18	19.86				
17	62.19	34.93	11.38	1940-1941	99.06	53.76	26.48
18	39.37	22.04	9.27	42	88.18	53.59	28.00
19	57.72	36.06	13.72	43	64.46	44.47	25.24
20	36.97	28.83	10.79	44	47.54	26.77	17.68
				45	60.42	39.21	22.22
1920-1921	84.33	49.53	16.33				
22	50.93	41.38	21.11	1945-1946	59.97	36.18	21.40
23	47.30	33.15	18.10	47	48.96	31.52*	17.13
24	26.84	20.41	6.17	48	68.20	41.27	16.33
25	55.81	35.98	13.82	49	43.35	25.61	17.50
				50	52.42	42.93	20.42
1925-1926	51.90	41.09	15.37				
27	70.76	51.02	22.44	1950-1951	74.87	53.15	26.55
28	59.25	38.67	13.00	52	83.51	60.21	36.10
29	36.96	20.75	9.82	53	68.17	42.45	19.70
30	57.59	38.12	14.50	54	66.53	44.20	16.79
				55	41.01	26.90	13.71
1930-1931	30.55	26.88	8.71				
32	50.69	31.01	17.32	1955-1956	88.58	60.11	28.74
33	33.70	21.63	10.98				
34	46.22	27.73	15.63				
35	62.31	40.65	22.44				
Average for 45 year period, 1911-12 through 1955-56					59.98	37.75	18.17

* Station moved to Quincy Ranger Station.

TABLE 11

STREAM GAGING STATIONS IN OR ADJACENT
TO THE UPPER FEATHER RIVER BASIN

Reference number	Stream	Station	Drainage area, in square miles	Periods of record	Source* of record
A-5-3675	Mountain Meadows Reservoir	near Prattville	---	1931-59	PG&E
A-5-3690	North Fork Feather River	above Prattville	---	1905-07'	USGS
A-5-3600	North Fork Feather River	near Prattville	507	1905-59	USGS
A-5-3660	Hamilton Branch	near Prattville	---	1905-07	USGS
A-5-3530	Butt Creek	above Almanor-Butt Creek Tunnel	67	1936-59	USGS
A-5-3500	Butt Creek	below Almanor-Butt Creek Tunnel	67	1938-59	USGS
A-5-3960	Caribou Penstock	at Butt Valley Reservoir	---	1939	PG&E
A-5-3475	Butt Creek	at Butt Valley	---	1905-21	USGS
A-5-3455	Butt Creek	near Caribou	---	1937-59	PG&E
A-5-4320	Indian Creek	near Crescent Mills	746	1906-09 1911-18 1930-59	USGS
A-5-4370	Indian Creek	near Taylorsville	532	1954-59	DWR
A-5-4450	Red Clover Creek	near Genesee	120	1954-59	DWR
A-5-4570**	Lights Creek	near Taylorsville	58	1954-59	DWR
A-5-4200	Spanish Creek	at Keddie	184	1911-59	USGS
A-5-4070	East Branch of North Fork Feather River	near Rich Bar	1,035	1950-59	USGS
A-5-4250	Spanish Creek	near Quincy	68	1954-59	DWR

TABLE 11 (continued)

STREAM GAGING STATIONS IN OR ADJACENT
TO THE UPPER FEATHER RIVER BASIN

Reference number	Stream	Station	Drainage area, in square miles	Periods of record	Source* of record
A-5-4630**	Wolf Creek	at Greenville	40	1954-59	DWR
A-5-3922	Grizzly Forebay	near Storrie	5	1930-59	PG&E
A-5-3300	Bucks Lake	near Bucks Lodge	28	1928-59	USGS
A-5-3248	Grizzly Creek	at Diversion Dam	---	1932-38 1940-59	PG&E
A-5-3920	Bucks Creek Powerhouse	at Storrie	---	1935-59	PG&E
A-5-3250	Grizzly Creek	near Storrie	5	1929-32 1933-44	USGS
A-5-3930	Bucks Creek Tunnel	at outlet	---	1934-36 1937-59	PG&E
A-5-3140	North Fork Feather River	at Big Bar	1,945	1911-30 1931-37 1939-59	USGS
A-5-2910	Wilenor Canal	near Yankee Hill	---	1929-59	PG&E
A-5-3100	North Fork Feather River	at Big Bend	---	1905-10	USGS
A-5-2950	Hendricks Canal	near Nimshew	---	1936-59	PG&E
A-5-2939	Miocene Canal	at head	---	1929-59	PG&E
A-5-2928	Miocene Canal	near Yankee Hill	---	1930	PG&E
A-5-2170	Concow Creek	near Yankee Hill	15	1927-52	USGS
A-5-2920	Spring Valley Ditch	near Yankee Hill	---	1927-52	USGS
A-5-2100	West Branch Feather River	near Yankee Hill	145	1930-59	USGS

TABLE 11 (continued)

STREAM GAGING STATIONS IN OR ADJACENT TO THE UPPER FEATHER RIVER BASIN

Reference number	Stream	Station	Drainage area, in square miles	Periods of record	Source* of record
A-5-5620	Smithneck Creek	near Loyalton	20	1937-54	DWR
A-5-5619	Smithneck Creek	near Loyalton	32	1954-59	DWR
G-7-2930	Little Truckee Ditch	at Summit	---	1937-56	DWR
A-5-5800**	Webber Creek	near Sierraville	37	1937-59	DWR
A-5-5740**	Hamlin Creek	near Sierraville	11	1937-43	DWR
A-5-5720	Miller Creek	near Sattley	8	1937-59	DWR
A-5-5380	Big Grizzly Creek	near Portola	45	1925-32 1950-59	USGS
A-5-5520	Little Last Chance Creek	near Chilcoot	85	1954-59	DWR
A-5-5360	Big Grizzly Creek	near Beckwourth	50	1906	USGS
A-5-5420	Middle Fork Feather River	near Portola	---	1955-59	DWR
A-5-5310	Middle Fork Feather River	near Clio	698	1925-59	USGS
A-5-5250	Middle Fork Feather River	at Sloat	793	1910-28	USGS
A-5-5230	Middle Fork Feather River	below Sloat	836	1940-59	USGS
A-5-5200	Middle Fork Feather River	near Nelson Point	898	1923-32	USGS
A-5-5100	Middle Fork Feather River	near Merrimac	1,078	1951-59	USGS
A-5-6300	South Fork Feather River	near La Porte	---	1927-33	USGS
A-5-6210	Lost Creek	below Lost Creek Dam	---	1947-59	USBR

TABLE 11 (continued)

STREAM GAGING STATIONS IN OR ADJACENT
TO THE UPPER FEATHER RIVER BASIN

Reference number	Stream	Station	Drainage area, in square miles	Periods of record	Source* of record
A-5-6200	Lost Creek	near Clipper Mills	30	1927-41 1948-59	USGS
A-5-6940	Oroville-Wyandotte Canal	near Clipper Mills	---	1927-41 1958-59	USGS
A-5-6920	Palermo Canal	at Enterprise	---	1911-59	USGS
A-5-6050	South Fork Feather River	at Enterprise	134	1911-59	USGS
A-5-5020	Feather River	at Bidwell Bar	1,353	1911-59	USGS
A-5-1140	Feather River	near Oroville	3,611	1934-59	USGS
A-5-1140	Feather River	at Oroville	3,611	1902-34	USGS
A-0-5775	South Honcut Creek	near Bangor	31	1950-59	USGS
A-0-5763	South Honcut Creek	at La Porte Road	69	1947-49	DWR

* PG&E - Pacific Gas and Electric Company
USGS - United States Geological Survey
DWR - Department of Water Resources
USBR - United States Bureau of Reclamation

** Earlier records of flow during irrigation season are available for stations at or near these locations.

drainage and tributary basins in which the gaging station is located. Also, most of the runoff records for the stations listed in Table 11 have been published by the United States Geological Survey in its Water Supply Papers; or by the Department of Water Resources in its reports on Sacramento-San Joaquin Water Supervision, in its annual reports on Watermaster Service, or in Bulletin No. 58, "Northeastern Counties Investigation".

Runoff Characteristics

Runoff from streams in the Upper Feather River Basin is derived for the most part from snowmelt. As a result, stream flow is maintained in the larger tributaries throughout the spring and early summer months. Tributaries of the North Fork of the Feather River, particularly those above Lake Almanor, have relatively uniform monthly flow characteristics. This is due to the fact that the predominantly volcanic soils readily absorb and store precipitation and snowmelt, and then yield runoff at a comparatively even rate of flow. The broad flat meadows in the Upper Indian Creek Basin, as well as those in Sierra and American Valleys, have a pronounced effect on downstream runoff characteristics. These meadows cause reduction in the flood peaks downstream when flood flows leave the natural channels and are stored by flooding over the adjoining flat lands. Also, in the early spring months water is delayed in transit, because it is diverted over these meadows by irrigation check dams.

Estimates of average monthly distribution of natural runoff at three stream gaging stations located in the upper reaches of the basin are presented in Table 12.

The seasonal flow of the Feather River is highly variable as indicated by records obtained at the gaging station near Oroville. The maximum seasonal runoff recorded at this station occurred in 1906-07, and amounted to 9,340,000 acre-feet, or 236 percent of the 45-year average. The minimum seasonal runoff

TABLE 12

ESTIMATED AVERAGE MONTHLY DISTRIBUTION
OF NATURAL RUNOFF AT SELECTED STATIONS IN
THE UPPER FEATHER RIVER BASIN
1911-12 THROUGH 1955-56

Month	Indian Creek near Crescent Mills		Middle Fork Feather River near Clio		Spanish Creek at Keddie	
	In acre-feet	In percent of seasonal total	In acre-feet	In percent of seasonal total	In acre-feet	In percent of seasonal total
October	3,200	1.1	2,560	1.1	3,000	1.6
November	9,000	2.4	5,240	2.2	6,700	3.5
December	23,300	6.2	13,480	5.7	15,600	8.2
January	27,100	7.2	18,650	7.9	18,600	9.8
February	39,300	10.4	26,070	11.1	25,800	13.5
March	63,400	16.9	44,420	18.9	30,200	15.9
April	95,300	25.3	55,930	23.8	37,600	19.7
May	64,400	17.0	32,000	13.6	28,100	14.7
June	25,600	6.8	17,630	7.5	12,500	6.6
July	12,400	3.3	9,400	4.0	6,100	3.2
August	8,000	2.1	5,940	2.5	3,500	1.8
September	4,800	1.3	3,980	1.7	2,800	1.5
TOTALS	375,800	100	235,300	100	190,500	100

recorded at this station occurred in 1923-24, and was 1,190,000 acre-feet, or about 30 percent of the 45-year average.

Quantity of Runoff

Runoff of Spanish Creek was measured at the station at Keddie throughout the 32-year base period. Runoff of the Middle Fork of the Feather River was measured at stations near Clio, Sloat and Nelson Point for a substantial portion of the base period. Estimates of flow for the portion of the period not covered by records near Clio and Nelson Point were made from correlations with the natural flows of the Middle Fork of the Feather River at Sloat. The runoff of Indian Creek was measured at the station near Crescent Mills for a substantial portion of the 32-year period, and estimates for the portion of the period not covered by records were derived from correlation with the natural flow of Spanish Creek at Keddie.

Estimates of seasonal runoff at dam sites within the Indian Creek stream system above Crescent Mills, the Spanish Creek stream system above Keddie, and the Middle Fork of the Feather River stream system above Bidwell Bar were based on estimated and gaged flows at the respective dam sites. For this purpose, an areal distribution of runoff was derived from linear correlations of area, elevation and precipitation. Although the drainage basins of these tributaries of the Feather River comprise about 45 percent of the area of the basin above the gaging station near Oroville, these tributaries produce only about 19 percent of the natural flow in Feather River near Oroville.

Estimates of the seasonal natural flow at selected stations on the Feather River and its tributaries above Oroville are presented in Table 13. Estimated natural seasonal runoff at selected stations in the Upper Feather River Basin is shown on Plate 4.

TABLE 13

ESTIMATED SEASONAL NATURAL RUNOFF AT SELECTED STATIONS
IN THE UPPER FEATHER RIVER BASIN
(In acre-feet)

Season	Feather River near Oroville	Feather River at Bidwell Bar	North Fork at Big Bar	South Fork at Enterprise	North Fork near Prattville	Indian Creek near Crescent Mills	Spanish Creek at Keddie	Middle Fork near Merrimac	Middle Fork near Clio	Middle Fork near Nelson Point
1911-12	2,289,000	696,000	1,371,000	136,000	550,000	153,000	96,000	444,000	98,000	248,000
13	2,871,000	924,000	1,535,000	178,000	615,000	216,000	118,000	614,000	120,000	289,000
14	8,185,000	2,546,000	3,441,000	453,000	1,048,000	824,000	392,000	1,728,000	595,000	1,285,000
15	6,132,000	1,760,000	2,592,000	375,000	940,000	381,000	289,000	1,168,000	207,000	477,000
1915-16	7,084,000	2,193,000	3,100,000	387,000	970,000	661,000	348,000	1,502,000	443,000	931,000
17	5,148,000	1,649,000	2,531,000	286,000	847,000	473,000	272,000	1,159,000	262,000	606,000
18	2,799,000	863,000	1,606,000	141,000	625,000	230,000	133,000	594,000	158,000	351,000
19	3,678,000	1,236,000	1,954,000	216,000	670,000	374,000	179,000	847,000	216,000	476,000
20	2,217,000	746,000	1,328,000	164,000	506,000	144,000	84,000	471,000	123,000	295,000
1920-21	6,077,000	1,992,000	2,801,000	413,000	896,000	578,000	278,000	1,284,000	274,000	625,000
22	5,134,000	1,858,000	2,578,000	308,000	804,000	654,000	273,000	1,346,000	350,000	822,000
23	3,094,000	1,141,000	1,708,000	194,000	587,000	230,000	130,000	781,000	225,000	528,000
24	1,307,000	341,000	819,000	66,000	396,000	75,000	54,000	210,000	46,000	112,000
25	3,170,000	1,060,000	1,574,000	237,000	567,000	173,000	107,000	652,000	148,000	338,000
1925-26	3,214,000	990,000	1,728,000	108,000	564,000	332,000	162,000	665,000	105,000	303,000
27	5,912,000	2,101,000	2,965,000	362,000	802,000	538,000	264,000	1,423,000	352,000	746,000
28	4,301,000	1,463,000	2,155,000	261,000	686,000	127,000	164,000	989,000	214,000	494,000
29	1,844,000	584,000	1,047,000	111,000	470,000	97,000	65,000	371,000	72,000	191,000
30	3,952,000	1,404,000	2,078,000	233,000	655,000	381,000	194,000	960,000	222,000	470,000
1930-31	1,443,000	426,000	930,000	72,000	422,000	85,000	58,000	268,000	60,000	152,000
32	3,324,000	1,260,000	1,696,000	217,000	551,000	272,000	148,000	867,000	189,000	435,000
33	2,000,000	625,000	1,223,000	106,000	459,000	123,000	85,000	417,000	76,000	188,000
34	2,017,000	637,000	1,187,000	121,000	438,000	104,000	72,000	400,000	69,000	169,000
35	4,270,000	1,500,000	2,057,000	252,000	680,000	389,000	189,000	1,065,000	241,000	557,000
1935-36	4,290,000	1,505,000	2,253,000	286,000	663,000	324,000	157,000	983,000	217,000	469,000
37	3,166,000	1,064,000	1,707,000	201,000	597,000	261,000	138,000	716,000	177,000	388,000
38	8,604,000	3,102,000	4,377,000	517,000	1,270,000	986,000	427,000	2,253,000	613,000	1,400,000
39	1,857,000	550,000	1,080,000	101,000	509,000	126,000	70,000	356,000	72,000	179,000
40	5,675,000	1,976,000	2,999,000	342,000	842,000	539,000	254,000	1,319,000	351,000	738,000
1940-41	6,482,000	2,118,000	3,434,000	425,000	999,000	462,000	276,000	1,395,000	242,000	639,000
42	6,652,000	2,198,000	3,544,000	384,000	998,000	600,000	296,000	1,502,000	361,000	789,000
43	5,620,000	1,979,000	2,995,000	325,000	910,000	587,000	238,000	1,346,000	430,000	870,000
44	2,872,000	869,000	1,695,000	154,000	613,000	254,000	113,000	582,000	162,000	329,000
45	3,736,000	1,317,000	1,963,000	240,000	660,000	284,000	158,000	871,000	196,000	442,000
1945-46	4,185,000	1,454,000	2,267,000	254,000	728,000	395,000	183,000	998,000	258,000	550,000
47	2,532,000	809,000	1,453,000	144,000	543,000	191,000	104,000	533,000	114,000	281,000
48	3,854,000	1,273,000	2,123,000	235,000	710,000	244,000	174,000	869,000	117,000	336,000
49	2,595,000	874,000	1,458,000	160,000	555,000	184,000	114,000	591,000	115,000	267,000
50	3,841,000	1,367,000	2,043,000	234,000	677,000	316,000	176,000	928,000	192,000	466,000
1950-51	5,691,000	2,078,000	2,824,000	386,000	795,000	488,000	245,000	1,383,000	358,000	895,000
52	7,962,000	2,884,000	4,043,000	476,000	1,097,000	945,000	398,000	2,083,000	717,000	1,324,000
53	5,211,000	1,677,000	2,890,000	322,000	911,000	490,000	234,000	1,133,000	249,000	578,000
54	4,230,000	1,291,000	2,318,000	254,000	822,000	319,000	195,000	843,000	155,000	391,000
55	2,472,000	750,000	1,432,000	142,000	575,000	160,000	102,000	488,000	100,000	277,000
1955-56	7,974,000	2,867,000	4,058,000	488,000	1,162,000	939,000	365,000	1,824,000	529,000	1,234,000
45-year Average	4,244,000	1,422,000	2,199,000	256,000	720,000	376,000	190,000	960,000	235,000	532,000

Flood flows in the upper basin occur in the winter and spring months. Although a warm rainstorm on an existing snowpack or snowmelt runoff is generally responsible for these floods, high intensity-long duration rainfall has also caused severe floods as evidenced by the December 1955 floods. Also, occasional spring thundershowers have caused high flood flows in localized areas.

As part of this investigation, studies were made on the frequency of flood occurrences. In these studies, a common base period was used for all stations considered and, where necessary, records were extended. A regional flood frequency diagram was constructed which enabled the determination of peak flows for various recurrence intervals at pertinent locations in the basin.

Ground Water

Studies of the underground hydrology of the valley fills in the Upper Feather River Basin were limited to brief geologic field reconnaissance, review of published geologic literature, and interpretation of logs of water wells. At the present time, a more detailed ground water investigation of two valleys, Sierra and Mohawk, is being conducted under the Northeastern Counties Ground Water Investigation. Presented below is a brief discussion of ground water geology and conditions in the major upper basin valleys.

Ground Water Geology

Exploitable ground water is confined mainly to the valley areas. The valleys in the Upper Feather River Basin were originally formed as structural dislocations and depressions of small parts of the huge mass of granitic and metamorphic rocks known as the Sierra Nevada block. The faulting and other structural dislocations probably began as early as 16 million years ago during late Miocene time. Since the formation of the structural depressions, erosion and sedimentation have modified the valleys into their present forms. With relation to the occurrence of ground water, the formations in each of the valleys may be divided into two groups, a water-bearing series and a nonwater-bearing series.

The water-bearing series in each valley includes alluvial fans, flood plain deposits, stream-channel deposits, stream-terrace deposits, and lake beds. All of these, with variations in volume and areal extent, occur in each of the valleys in the Upper Feather River Basin. In addition, wind-blown sand deposits, glacial deposits and lake terrace deposits occur in some of the valleys. Permeability of the unconsolidated deposits is extremely variable, ranging from very low values for the lake sediments to very high values for stream-channel gravels. Also included in the water-bearing series are the permeable portions of the younger volcanics. The massive basaltic and andesitic lavas are unjointed and, therefore are relatively impermeable as are the andesitic mudflows. The thin lava flows are characteristically fractured and jointed, and may be extremely permeable.

The nonwater-bearing series includes all of the granitic and metamorphic rocks which underlie the entire area and which are exposed over most of the area. Permeability of these rocks is generally low, but some ground water is recoverable from joints, fractures, and weathered zones.

Sierra Valley

Sierra Valley is one of the larger valleys in the Sierra Nevada and is a structural depression formed by faulting but modified by erosion and sedimentation. Although its outline is somewhat irregular, the valley is about 20 miles long from northeast to southwest, and about 12 miles wide, and includes an area of approximately 155 square miles. The valley is drained by the Middle Fork of the Feather River.

Sierra Valley is almost completely surrounded by volcanic flows and breccias erupted from ancient vents and fissures in the vicinity. The volcanic rocks probably extend under much of the valley. Granitic rocks outcrop along the valley margins in three general areas, west of Sierraville and Calpine, near Chilcoot, and near Beckwourth.

Most of the sediments that fill the valley were deposited in a lake which occupied the area almost continuously until it was drained by the Feather River during the Recent geologic past. The remainder of the sediments are stream deposits. The sediments are very thick--a well drilled near the center of the valley prior to 1911 penetrated over 1,200 feet of unconsolidated deposits predominantly "blue clay" without encountering bedrock. Hot water flowed from the well.

Ground water is confined under extensive, thick, lake sediments, and flows under artesian pressure from many deep wells located in various portions of the valley. The permeable sand and gravel found around a large portion of the margin of the valley act as forebay areas for the deep aquifers. Well logs indicate that the deep aquifers are thin and that ground water production from them would be limited.

The free ground water table is at the surface over portions of the valley and is only a few feet below the surface over the remainder of the valley. Evidence of the high ground water table is found in the marshy areas along the west side of the valley and in standing water in drainage ditches.

Several major faults have been mapped to the margins of Sierra Valley and have been projected beneath the alluvium in the valley. No movement on any of these faults has been recorded. The effect which the faults may have on ground water movement could not be determined. However, degradation of the waters in the deeper aquifers in the western and central portions of the valley has been attributed to movement of hot mineralized waters into the ground water basin along one of the projected faults.

The Sierra Valley ground water basin is rimmed by bedrock which may allow subsurface inflow, but probably prevents subsurface outflow from the basin. The only losses of ground water from the basin, therefore, probably result from consumptive use and from discharge to the surface followed by outflow in the Middle Fork of the Feather River.

Under present conditions of development, extraction of water from the ground water basin could be increased. Such increase in draft would undoubtedly be accompanied by recession of ground water levels in areas of pumping thereby increasing percolation rates and thus conserving more of the runoff. Additional ground water development could, therefore, increase the water supply available to Sierra Valley.

American Valley

American Valley (including Thompson Valley) is an irregularly shaped, structural depression with a maximum length of about eight miles and a maximum width of three miles. The alluviated part of the valley covers an area of about seven square miles. Slate, phyllite, graywacke, quartzite, and lenses of sandy limestone, all part of the Calaveras formation, underlie the valley and outcrop in the hills which border the valley. These are considered to be nonwater-bearing.

The water-bearing series includes unconsolidated gravel, sand, and silt deposited in stream channels and on flood plains. Interbedded with these are silts and clays deposited in an ancient lake which was periodically filled and drained from the time of its structural origin. Permeability of the sediments varies over the area. The specific yield for the water-bearing series in the valley is estimated to vary between 5 and 10 percent, with possibly somewhat higher values near Spanish Creek. The ground water is apparently of good quality; no highly mineralized ground water have been reported.

Reports of well drillers indicate partial confinement under pressure of water in the deeper water-bearing zones of American Valley. Recharge to the ground water is supplied by Spanish Creek in the western part of the valley, Mill Creek in the central part, and Greenhorn Creek at the east end. Additional recharge may result from underflow through joints in the bedrock around and under the valley. Some ground water returns to the surface in Spanish Creek at the outlet of the valley.

Increased pumping of ground water in American Valley would lower the water table and thus allow additional recharge to the ground water basin. Such development could increase the supply of water available to the valley.

Indian Valley

Indian Valley is a deep, irregularly shaped, structural depression filled with alluvial sediments. The maximum width of the valley is a little more than two miles, yet the valley extends about nine miles from Taylorsville northwest to Greenville, and about eight miles from the outlet near Crescent Mills northeast to the upper end of North Arm. The area of the valley floor is about 20 square miles.

A thick section of metamorphic rocks, ranging in age from pre-Silurian to Jurassic, underlies the valley and is exposed in the surrounding mountains. These rocks are considered to be nonwater-bearing. The water-bearing sediments in the valley include unconsolidated, interbedded, and intermixed deposits of gravel, sand, silt, and clay. The more abundant silt and clay deposits were laid down in an ancient lake which occupied the valley intermittently. The gravel, sand, and silt were deposited by streams which flowed through the valley during the inter-lacustrine intervals.

Analyses of logs of wells indicate relatively low permeability and consequently very low specific yield for the bulk of sediments. The overall specific yield is estimated at approximately four percent. Higher specific yields are encountered in the North Arm and along Indian Creek above Taylorsville.

The amount of recharge to the ground water basin is limited by the high-water table. The water table is sufficiently high to cause swampy ground in parts of the valley. Some ground water rises in Indian Creek near the valley outlet and flows down the creek, but most remains trapped within the basin.

Further development of ground water supplies in the valley would lower the water table thereby increasing percolation of streams and thus conserving more of the runoff. Additional ground water development could, therefore, increase the water supply available to Indian Valley.

Mohawk Valley

Mohawk Valley is a long, northwest-trending, structural trough associated with a major fault system which slices through the area from Lake Tahoe to American Valley. The water-bearing series in Mohawk Valley includes Recent alluvium, Pliocene and Pleistocene lake beds, and Pleistocene glacial deposits. The alluvium consists of gravel, sand, and silt deposited on the flood plain and along the channel of the Middle Fork of the Feather River. Available information indicates that the area covered by alluvium is about eight square miles. An additional 12 or more square miles of the valley and adjacent hills have been mapped as Pliocene and Pleistocene beds deposited in an ancient lake called Mohawk Lake. These deposits include beds of silt and clay at lower levels, and terraces of sand and gravel around the margins. Glacial deposits, consisting of poorly sorted angular boulders, gravel, sand, and silt, have been mapped along the southwest margin of the valley. These are the most extensive of the glacial deposits in Plumas County and are hundreds of feet thick near Johnsville. Mohawk Lake had a surface area of about 35 square miles during the glacial epoch. The deposits at the highest lake stage were largely rather fine material--andesitic and morainal detritus. The higher lake beds and the glacial deposits have subsequently been deeply eroded.

Granitic and metamorphic rocks, classified as nonwater-bearing, are exposed to the south and southwest of the valley. The northeast margin of the valley is formed predominantly of volcanic rocks (principally andesites) with occasional outcrops of granitic and metamorphic rocks.

Mountain Meadows Valley

Mountain Meadows Valley is located in Lassen County south of Westwood. The alluviated portion of the valley, not covered by Mountain Meadows Reservoir, has an areal extent of about 10 square miles. The alluvium consists of detritus from the complex of igneous and metamorphic rocks which outcrop around the valley, as well as some reworked auriferous gravels.

A variety of rock units is exposed around the valley, including meta-andesite of Carboniferous age; hornfels, slate, limestone, graywacke, quartzite, and granite of Jurassic age; rhyolite, andesite, and basalt of Tertiary and Quaternary age, and Tertiary auriferous gravels.

No logs of water wells nor any other data on the ground water of Mountain Meadows Valley are available. This lack of information precludes making any estimate of specific yield or storage capacity of the water-bearing sediments.

Meadow Valley

Meadow Valley is an irregularly shaped, structural depression located six miles west of Quincy. The structural deformation which formed the depression occurred along a major fault between Meadow Valley and Spanish Peak. The vertical displacement along this fault is estimated to be 2,000 to 3,000 feet. Evidence indicates that a lake was formed in the depression in early Pleistocene time (about one million years ago). Auriferous gravels accumulated on the shores of the lake until an outlet to American Valley was finally formed through Spanish Creek. The matrix of the gravels contains numerous shards of volcanic glass.

Tertiary auto-brecciated andesite flows (sometimes referred to as volcanic mudflows or tuff-breccias) form the hills on the north and south margins of Meadow Valley. Underlying these volcanic rocks and exposed in the mountains both east and west of the valley, are massive serpentines, meta-sedimentary rocks of the Calaveras formation, and amphibolites (a tough, green meta-volcanic rock).

Recent alluvium and Pleistocene lake deposits are the only water-bearing formations found in the area. The alluvium covers an area of about three square miles, and the lake beds probably add another three square miles or so to the areal extent of the water-bearing sediments. The average specific yield for the water-bearing sediments is estimated at approximately five per-cent. Well logs indicate occasional clean water-bearing sand and gravel; clay and silt make up the bulk of the deposits.

Recharge of the ground water is by percolation from streams and infiltration of rainfall. Ground water movement appears to be toward the two valley outlets where Spanish Creek and Meadow Valley Creek leave the valley.

Lake Almanor Valley

Lake Almanor Valley is enclosed on three sides by Tertiary volcanic rocks. Metamorphic rocks outcrop along the east margin of the lake. The area covered by discontinuous segments of alluvium along the shores of Lake Almanor is approximately seven square miles. The town of Chester is located within the largest alluvial segment at the north end of the lake. The water-bearing series in this area includes both alluvial deposits and some of the volcanic rocks. The alluvial sediments are gravel, sand, silt, and clay, which are interbedded and intermixed. The proportion of each varies widely throughout the area, but clay and silt are predominant. The specific yield is estimated at about five percent.

Logs of wells in the valley indicate that layers of pyroclastic debris are interbedded with the alluvial sediments and that alluvial deposits are interbedded with the lava flows and ash beds. Well drillers have indicated that brown porous lavas form the water-bearing horizons in the predominantly volcanic areas.

Ground water recharge to the area comes from percolation of surface waters, both rainfall and stream flow, and subsurface underflow from the volcanic rocks. Normally, the slope of the water table and the flow of ground water is toward Lake Almanor, but subsurface flow of water from the lake may occur toward areas of heavy pumping.

Grizzly Valley

Grizzly Valley, located six miles north of Portola, rates third in area of alluvium among the valleys in the Upper Feather River Basin but ranks low in all forms of development including use of its ground water. The valley parallels the northwesterly trend common to the major structural features at the north end of the Sierra Nevada. The adjacent hills consist of Tertiary volcanic rocks. Granitic and metamorphic rocks outcrop near the valley floor at the upper end of the valley. These rocks form the low terraced hills and gorge at the valley outlet, and probably underlie the entire valley. The alluvium and terrace deposits in the valley consist of gravel, sand, silt, and clay. These deposits are probably relatively thin.

No data are available on which to base estimates of specific yield and ground water storage capacity of Grizzly Valley. However, the permeability and yield of the sediments are probably low. A significant portion of the valley would be inundated by the proposed Grizzly Valley Reservoir.

Clover Valley

Clover Valley is a large, shallow valley in an area of volcanic rocks, about 12 miles northwest of Beckwourth. Even though the valley itself appears to be quite large, its alluviated portion is limited to about six square miles. The remainder of the floor of the valley is covered with lava flows. No logs of wells are available. However, the alluvium in the valley is probably quite thin, and permeability is probably moderate to low. Small quantities of ground water probably could be produced from the alluvium and some of the jointed lava flows which underlie and surround the valley.

Little Last Chance Valley

Little Last Chance Valley is a shallow, somewhat irregular valley which is apparently the product of erosion. Bedrock in the area consists of Tertiary volcanic rocks and Jurassic granitic rocks. The alluviated portions of the valley are divided topographically into four segments, the total area of which is abcut five square miles. The climate is semiarid, but, in spite of this, a small amount of stream flow is maintained in Little Last Chance Creek through the late summer and fall by effluent ground water from the volcanic rocks. Logs of wells and hydrologic data are not available, but geologic evidence indicates that the alluvium in each of the four segments is relatively thin and that ground water production would be limited.

Squaw Valley

Squaw Valley is a broad, shallow valley near the crest of the Sierra Nevada. The valley was formed and is drained by Squaw Queen Creek. Basaltic and andesitic lava flows outcrop over much of the floor of the valley. The alluviated portion of the valley is a narrow strip near Squaw Queen Creek. The alluvium has an area of approximately three square miles and consists of gravel, sand, and silt. Ground water occurs in the alluvium and in joints and fractures in the underlying volcanic rocks.

Lack of logs of wells or other data on ground water in Squaw Valley precludes estimation of specific yield and storage capacity of the water-bearing formations.

Genesee Valley

Genesee Valley is a long, narrow valley having an alluviated area of approximately three square miles. The alluvium consists predominantly of sand and gravel deposited on the flood plain of Indian Creek. Interbedded with the sand and gravel are silt and clay lenses which were deposited in a lake which occupied the valley intermittently in the past.

The valley is underlain and surrounded by a complex of metamorphic and igneous rocks which range in age from Carboniferous to Jurassic, and are considered to be nonwater-bearing.

Recharge to the ground water is by percolation of stream flow and rainfall. Ground water discharge occurs as stream flow and evapotranspiration. Subsurface outflow presumably is negligible due to underlying, nonwater-bearing, metamorphic rocks.

The depth, specific yield, and storage capacity of the alluvial deposits cannot be estimated because adequate data are not available. Based on geologic reconnaissance, the alluvium is probably quite deep and permeable, and yield of wells should be high.

Water Quality

Information pertinent to the quality of waters in the Upper Feather River Basin indicates that water supplies developed by the proposed projects would be of good to excellent quality and suitable for most beneficial uses.

Results of water quality studies are discussed below. More detailed information is available in the files of the Department of Water Resources.

Mineral analyses of water samples from Indian Creek, Last Chance Creek, Squaw Queen Creek, and Red Clover Creek indicate that the water is of excellent quality and suitable for most beneficial uses. Reservoirs would store water from these creeks and would yield water of similar quality. Since these reservoirs would be located above anticipated industrial and agricultural development, it is improbable that future development would impair the quality of the water. Sodium-type water from a few springs found within the reservoir sites should have little influence on the quality of water in storage.

A similar situation exists at the Meadow Valley site, and a water supply of excellent quality is anticipated. Diversion of Middle Fork of the Feather River water from Nelson Point Reservoir to Meadow Valley Reservoir should have little effect on the quality of water.

The water in Yellow Creek in Humbug Valley is of excellent quality. However, the presence of mineralized springs which drain into the valley may cause a slight impairment of the quality of the water available for storage during periods of low flow. Flows from these mineralized springs normally decrease along with reduced stream flows. Therefore, while 6.0 parts per million of boron were found in one such spring, dilution of this water by relatively larger stream flows should reduce the boron to harmless concentrations.

Water of excellent quality is anticipated for storage in the proposed Swayne Reservoir on French Creek, even during periods of low flow.

Water released from the proposed Frenchman and Grizzly Reservoirs should be of a calcium bicarbonate-type and of excellent quality. Good quality water from springs constitutes a large portion of the water supply at both of these reservoir sites. Since these reservoirs would be located upstream from Sierra Valley, there is little or no possibility of degradation due to future development in the valley.

Sheep Camp Reservoir will be supplied by water of high quality and the quality of water released from the reservoir should closely approximate the quality of inflow. Unless the water of the streams supplying the reservoir is degraded by mining and lumbering wastes, the reservoir releases should remain excellent in quality. Mixing of the excellent quality surface water with the poorer quality ground water in the west central portion of Sierra Valley would enhance the quality of the ground water.

The Middle Fork of the Feather River at Nelson Point and Clio dam sites has, at present, water of excellent quality. Storage of this water in Clio Reservoir should not affect the quality, provided upstream degradation does not occur. At present, irrigation return flows and runoff from highly mineralized hot springs and artesian wells in Sierra Valley are not of sufficient quantity to cause quality impairment of the Middle Fork of the Feather River. However, following construction of Frenchman, Grizzly Valley, and Sheep Camp Projects, it is believed that agricultural activity will expand and increase the quantity of irrigation return flows. Although the quality of water to be stored in Clio and Nelson Point Reservoirs may be degraded by increased return flow from Sierra Valley, it should be suitable for most beneficial uses.

Runoff from the upper watersheds of the North and Middle Forks of the Feather River is of excellent quality and suitable for most beneficial uses. However, there are several highly mineralized hot springs. Because of the small flows from the springs, they cause only localized and minor impairment of the quality of the major supplies. Sierra Valley, the largest ground water basin in the area of investigation also produces some ground water of poor quality. Warm mineralized ground waters are produced from wells in the west central portion of the valley near the highly mineralized Marble Hot Springs. This water, probably originating in faults which occur throughout this area, is a sodium chloride-type water and generally contains excessive concentrations of boron and an excessive percent sodium. Analyses of samples from wells throughout the valley indicate that a zone of poor quality water exists in the central portion of the valley. The quality of ground waters in the rest of Sierra Valley appears to improve as the distance from the west central area increases. The quality becomes excellent at the periphery of the valley. This suggests that a mixing of the highly mineralized ground water occurs in the central section of the valley.

In summary, water delivered from the proposed reservoirs in the Upper Feather River Basin would be of good to excellent quality and suitable for most beneficial uses. This prediction is based on the location of reservoir sites which, in general, are in isolated areas above possible sources of existing or anticipated degradation. In addition, the water available for storage at these reservoir sites is of excellent quality.

CHAPTER V. WATER UTILIZATION AND REQUIREMENTS

Extensive studies of the use of water within the Upper Feather River Basin under present and future conditions of development were made for the Northeastern Counties Investigation. The results of these studies have previously been published in detail in the publication, "Report on Upper Feather River Service Area", April 1955, and in Bulletin No. 58, "Northeastern Counties Investigation".

The basic data, methods of obtaining and evaluating the data, and the estimates derived primarily from information developed during the Northeastern Counties Investigation are presented in this chapter. Contained herein, and considered necessary for proper evaluation of the estimates of present and ultimate water requirements, are results of an inventory of present land use, a land classification survey, estimates of unit values of water use and a pattern of ultimate land use.

In connection with the discussion of the nature and extent of water utilization and requirements, both at the present time and under probable conditions of ultimate development, the following terms are used as defined.

Water Utilization--The employment of water by nature or by man, whether consumptive or nonconsumptive, as well as irrecoverable losses of water incidental to such employment. It is synonymous with the term water use.

Consumptive Use of Water--The water consumed by vegetative growth in transpiration and building of plant tissue, and water evaporated from adjacent soil and from foliage. Also, water consumed and evaporated by urban and nonvegetative types of land use.

Applied Water--Water delivered to a farmer's headgate in the case of irrigation use, or to an individual's meter or its equivalent, in case of urban use. It does not include direct precipitation.

Water Requirement--Water needed for all beneficial uses and for unavoidable losses incidental to such use.

Demands for Water--Those factors pertaining to specific rates, times, and places of delivery of water, losses of water, quality of water, etc., imposed by the control, development, and use of water for beneficial purposes.

Effective Precipitation--The portion of direct precipitation which is consumptively used and which does not run off or percolate to ground water.

Irrigation Efficiency--The ratio of consumptive use of applied water to the total amount of applied water for a specific area, commonly expressed as a percentage.

Water Service Area Efficiency--The ratio of consumptive use of applied water in a given service area, with re-use of water where possible, to the gross amount of water delivered to the area, expressed as a percentage.

Present--Land use and water supply conditions prevailing during the period from 1954 to 1956.

Ultimate--Conditions after an unspecified but long period of years in the future, when land use and water supply development will be at a maximum and essentially stabilized.

Present Water Service Areas

The initial step in evaluating water requirements of the Upper Feather River Basin was to determine by surveys the nature and extent of present land as related to use of water. As irrigated agriculture is by far the greatest user of applied water, a complete survey was made of the present pattern of irrigated land. Present water service areas include areas of urban and suburban lands, and areas of principal reservoir surfaces, since these, in addition to irrigated agriculture, constitute significant uses of water. A description of the procedures used to determine present water service areas, as well as presentation of results, follows.

Presently Irrigated Lands

Presently irrigated lands comprise all agricultural lands that receive water applied from surface or ground water sources. Lands utilizing water directly from a high-water table, either naturally or induced, are also considered as irrigated. Surveys of these lands were accomplished by field inspection, using aerial photographs to delineate the boundaries of the various classifications of lands. The classified areas were then delineated on base maps, measured, and the data compiled. The locations and amounts of irrigated lands within adjudicated areas of Indian Creek and the Middle Fork of the Feather River above Beckwourth were obtained from data provided by the Watermaster Service of the Department of Water Resources.

The crop types classified by field surveys included alfalfa, improved and meadow pasture, grain and grain hay, and deciduous orchard. As agriculture in the Upper Feather River Basin is devoted mainly to the production of cattle, forage and hay crops are the predominant irrigated crop types. Irrigated pasture crops were grouped in accordance with differences in water use. Improved pasture is land with improved irrigation facilities and is generally planted to selected grasses and legumes. Meadow pasture consists of unimproved lands which sustain native grasses, such as rush and wire grasses. Meadow pasture utilizes more water than improved pasture because of high-water table conditions. Pasture is the principal irrigated crop in the upper basin. Of the 76,000 acres presently irrigated within the basin, 20,000 acres are in improved pasture and 52,000 acres are in meadow pasture. The remaining acreage is devoted primarily to alfalfa and grain hay.

The estimated acreage of presently irrigated lands in the hydrographic units of the Upper Feather River Basin is presented in Table 14. The tabulated values are for gross irrigated areas without reduction for roads, farmsteads, and other nonwater-using areas. Presently irrigated lands and boundaries of hydrographic units are delineated on Plate 5. The area delineated as presently irrigated lands includes agricultural lands irrigated by man-made and natural methods, and swamp and marsh lands.

Urban and Suburban Lands

Present urban and suburban lands include the developed areas of the cities and towns, sawmills, small communities, industrial areas, and resorts. These lands comprise the gross developed area including homes, business districts, vacant lots, and industrial areas. These urban and suburban areas are not limited by municipal boundaries or any specific density of development. The acreages of present urban and suburban lands for each hydrographic unit in the Upper Feather River Basin are tabulated in Table 14.

Principal Reservoirs

The area occupied by principal reservoirs comprises approximately 30 percent of the total water service areas of the Upper Feather River Basin. Principal reservoirs include man-made reservoirs, as well as those natural lakes in which the storage is controlled by dams. The acreages of the average

Haying Near Quincy

water surface area of the principal reservoirs in each hydrographic unit in the basin are tabulated in Table 14.

TABLE 14

PRESENT WATER SERVICE AREAS (1954-1956) WITHIN THE UPPER FEATHER RIVER BASIN

(In acres)

Reference number	Hydrographic unit	Type of land use: Irrigated lands: Alfalfa	Irrigated lands: Pasture: Improved	Irrigated lands: Pasture: Meadow	Irrigated lands: Grain and grain hay	Irrigated lands: Deciduous orchards	Irrigated lands: Total irrigated	Urban and suburban lands	Principal reservoirs
1	North Fork Feather River	0	1,530	10,390	0	0	11,920	530	30,960
2	East Branch Feather River	490	4,650	11,660	990	80	17,860	280	140
3	Sierra Valley	1,210	11,300	26,310	1,370	0	40,190	100	10
4	Middle Fork Feather River	0	2,660	3,580	0	20	6,260	250	230
5	South Fork Feather River	0	80	30	0	10	120	0	90
	TOTALS	1,700	20,220	51,960	2,360	110	76,350	1,160	31,370

Probable Ultimate Pattern of Land Use

Under ultimate conditions of development, it is probable that irrigated agriculture will continue to constitute the primary applied water requirement in the Upper Feather River Basin. Accordingly, considerable emphasis was placed upon the classification of potentially irrigable lands and upon the forecast of the probable ultimate crop pattern. Where timber production in the basin is one of the major factors in the economy, careful attention was given to classification of lands that are better-suited to forest production even though satisfactory for agricultural purposes. Estimates were made of the areas of suitable land that may be utilized as urban and suburban areas under ultimate development. Recognizing the importance of the recreation potential of this mountainous area to the local economy, as well as to the people of California, estimates of areas of land that may be used for recreation were made as a step toward estimating recreational water requirements. Areas of principal reservoirs that may exist under ultimate development were determined because of their bearing on recreational development as well as the additional water requirement that reservoir evaporation would create. Methods used to determine the ultimate pattern of land use in the basin, and the results of these studies, are included in the following discussion.

Irrigable Lands

The extent and location of irrigable lands in the Upper Feather River Basin were determined by field surveys from which lands were grouped into appropriate classifications of irrigability and crop adaptability. Considerable emphasis was placed on this classification procedure and projection of probable ultimate crop pattern, since water requirements to meet consumptive use of irrigated agriculture constitute the most significant portion of the ultimate applied water requirements of the basin. Ultimate water requirements for irrigation purposes were estimated at more than 60 percent of the total requirements.

Lands classified as suitable for irrigation development were segregated into three broad topographic groups: smooth-lying valley lands, slightly sloping and undulating lands, and steeper and more rolling lands. Where other conditions limited the suitability of the lands to produce climatically adapted crops, the three broad classes were further subdivided in accordance with the nature of the limitations. Such limiting conditions included shallow soil depths, rockiness, high-water tables, coarse textures with low moisture holding capacities, very fine textures limiting the effective depth, and an excess of soluble salts or exchangeable sodium.

In certain of the mountain and foothill areas in the upper basin, lands are found with soils and physical characteristics which permit irrigation development. However, due to climatic and other factors associated with present utilization of these lands, they were classified as best-suited to remain under some type of forest management. In general, these lands lie at elevations where lengths of growing season based on killing frosts greatly limit crop adaptability.

In other areas, where the economy is influenced by the production of livestock with the accompanying demand for range land, particularly in the national forests, it was assumed that the marginal land classes would remain as grazing land under general forest management practices. Other irrigable areas adjacent to high mountain lakes and streams are suitable for recreational activities. These areas were assumed to remain under forest management and were not considered as potential agricultural lands.

In Table 15 there is presented a description of the land classification standards for irrigable lands used in the Northeastern Counties Investigation and adopted for use in this bulletin. The land classification procedure used during the investigation consisted basically of an examination of the soil characteristics and the physical character of the landscape. Field mapping was done on aerial photographs having a scale of 1 to 20,000, which is about three inches to one mile. The character of the soils was established by examination of materials from test holes, road cuts and ditch

TABLE 15

LAND CLASSIFICATION STANDARDS
FOR
IRRIGABLE LANDS

Land Class	Characteristics
V	Smooth lying valley lands with slopes up to six percent in general gradient, in reasonably large-sized bodies sloping in the same plane; or slightly undulating lands which are less than four percent in general gradient. The soils have medium to deep effective root zones, are permeable throughout, and free of salinity, alkalinity, rock or other conditions limiting crop adaptability of the land. These lands are suitable for all climatically adapted crops.
Vw	Similar in all respects to Class V, except for the present condition of a high-water table which in effect limits the crop adaptability of these lands to pasture crops. Drainage and a change in irrigation practice would be required to affect the crop adaptability.
Vs	Similar in all respects to Class V, except for the presence of saline and alkaline salts, which limits the present adaptability of these lands to crops tolerant to such conditions. The presence of salts within the soil generally indicates poor drainage and a medium-to high-water table. Reclamation of these lands will involve drainage and the application of additional water over and above crop requirements in order to leach out the harmful salts.
Vl	Similar in all respects to Class V, except for having fairly coarse textures and low moisture-holding capacities, which in general make these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
Vp	Similar in all respects to Class V, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops, such as irrigated grain and pasture.
Vr	Similar in all respects to Class V, except for the presence of rock on the surface or within the plow zone in sufficient quantity to prevent use of the land for cultivated crops.
Vls	Similar in all respects to Class V, except for the limitations set forth for Classes Vl and Vs, which makes these lands best suited for the production of deep-rooted, salt-tolerant crops.
Vps	Similar in all respects to Class V, except for the limitations set forth for Classes Vp and Vs, which restrict the crop adaptability of these lands to shallow-rooted, salt-tolerant crops.

TABLE 15 (continued)

LAND CLASSIFICATION STANDARDS
FOR
IRRIGABLE LANDS

Land Class	Characteristics
Vpr	Similar in all respects to Class V, except for the limitations set forth for Classes Vp and Vr, which restrict the crop adaptability of these lands to noncultivated crops.
H	Rolling and undulating lands with slopes up to a maximum of 20 percent for rolling large-sized bodies sloping in the same plane; and grading down to a maximum slope of less than 12 percent for undulating lands. The soils are permeable, with medium to deep effective root zones, and are suitable for the production of all climatically adapted crops. The only limitation is that imposed by topographic conditions, which affect the ease of irrigation and the amount of these lands that may ultimately be developed for irrigation.
Hl	Similar in all respects to Class H, except for having fairly coarse textures and low moisture-holding capacities which in general makes these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
Hp	Similar in all respects to Class H, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Hr	Similar in all respects to Class H, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of the land to noncultivated crops.
Hpr	Similar in all respects to Class H, except for depth of the effective root zone and the presence of rock on the surface or within the root zone in sufficient quantity to restrict use of these lands to noncultivated crops.
Ht	Similar in all respects to Class H, except for topographic limitations. These lands have smooth slopes up to 30 percent in general gradient for large-sized bodies sloping in the same plane, and slopes up to 12 percent for rougher and more undulating topography. These lands will probably never become as highly developed as other "H" classes of land.
Htp	Similar in all respects to Class Ht, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Htr	Similar in all respects to Class Ht, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of these lands to noncultivated crops.

TABLE 15 (continued)

LAND CLASSIFICATION STANDARDS
FOR
IRRIGABLE LANDS

Land Class	Characteristics
Htpr	Similar in all respects to Class Ht, except for depth of the effective root zone and the presence of rock on the surface or within the root zone, which limits use of these lands to noncultivated, shallow-rooted crops.
F	Presently forested lands, or lands subject to forest management, which meet the requirements for irrigable land but which, because of climatic conditions and physiographic position, are better suited for timber production or some type of forest management program rather than for irrigated agriculture.

banks, together with observation of the type and quality of natural vegetation and crops. The presence of rock, high-water tables, alkalinity, and salinity were noted. Representative slopes were measured to determine the degree of slope. Considering these factors, the appropriate crop adaptability class of the land was determined and delineated on aerial photographs. In certain areas, where similar surveys had been accomplished previously by other agencies of the State and Federal Government, the previous work was used as an aid to the department's land classification.

From field surveys, it was determined that the gross irrigable area within the Upper Feather River Basin is about 196,000 acres. Irrigable valley lands comprise 133,000 acres and irrigable hill lands comprise 63,000 acres. In addition, there are 147,000 acres of irrigable land classified as best suited to forest management. No crop pattern or future water requirement is contemplated for this latter classification. Results of the classification of irrigable lands in the Upper Feather River Basin are presented in Table 16. The irrigable valley and hill lands and other irrigable lands best suited to forest management are shown on Plate 5.

Even in the most intensively developed areas of irrigated agriculture, not all of the land is cultivated nor does all irrigable lands receive water every year. Since the results of the land classification survey were in terms of gross area, it was necessary to determine the net acreage that might ultimately be irrigated in any one season. This determination depended upon one or more of the following factors: (1) quality of the land and crop rotation; (2) irrigable areas utilized for purposes other than agriculture; (3) inclusions of nonirrigable land; (4) size, shape, and location of irrigable land; (5) ease of development of irrigable lands; and (6) economic conditions. The effects of these factors on gross irrigable area is presented in the following discussion.

TABLE 16

CLASSIFICATION OF IRRIGABLE LANDS IN THE UPPER FEATHER RIVER BASIN
(In Acres)

Hydrographic unit		Irrigable valley land class									Irrigable hill land class									Gross irrigable area	Irrigable lands best suited to forest management
Reference number	Name	V	Vw	Vs	Vl	Vp	Vr	Vls	Vps	Vpr	H	Hl	Hp	Hr	Hpr	Ht	Htp	Htr	Htpr		
1	North Fork Feather River	220	7,540	0	0	270	1,690	0	0	260	6,740	0	0	2,280	0	3,720	50	1,490	0	24,260	97,610
2	East Branch Feather River	12,200	9,390	0	100	800	1,090	0	0	160	6,240	0	250	4,680	530	190	0	290	0	35,920	8,450
3	Sierra Valley	29,030	25,740	3,600	10,700	17,340	1,750	1,230	4,520	280	8,930	900	2,180	5,600	620	1,450	40	4,250	0	118,160	6,650
4	Middle Fork Feather River	1,130	3,100	0	0	0	400	0	0	0	6,440	0	410	1,760	270	2,040	40	370	100	16,060	22,350
5	South Fork Feather River	10	0	0	0	0	0	0	0	0	190	0	0	240	0	410	0	350	0	1,200	11,550
	TOTALS	42,590	45,770	3,600	10,800	18,410	4,930	1,230	4,520	700	28,540	900	2,840	14,560	1,420	7,810	130	6,750	100	195,600	146,610

It is expected that, in the future, the higher quality irrigable lands would be intensively developed for irrigation and would remain in relatively continuous operation, whereas lands of poorer quality and of limited crop adaptability would only be in production when favorable economic conditions permit. Even though it is assumed that all irrigable lands will receive water service, the effect of crop rotation would reduce the acreage irrigated seasonally.

It is anticipated that there will always be a portion of the irrigable lands that would be occupied by urban types of development, farm lots, highways, railroads, canals, industrial establishments, etc. The nature of the agricultural development will, to some extent, determine the amount of certain of these nonagricultural land uses. For example, orchard and truck farming areas ordinarily include more land use for roads and farmsteads than areas where field crops are dominant.

It was not possible to delineate all of the small areas of nonirrigable land such as areas containing rock, shallow soil, poor drainage, or excessive slopes which occur within the lands classed as irrigable. The occurrence of these small plots of nonirrigable lands, which are included within the areas classed as irrigable, varies generally with the detail of the survey and classes of lands being surveyed. The occurrence is greatest in the marginal classes.

It is apparent that small, irregularly shaped plots of land, particularly those isolated from other irrigable lands, cannot be irrigated as readily or completely as large, regularly shaped, compact units. Ownership boundaries also exert an influence, since small, isolated ownerships probably will never be developed.

The inherent difficulties encountered in developing and serving water to lands with more adverse topographic conditions will tend to prevent them from being utilized completely. This is particularly true of those lands with hilly topography which could not be served completely by a gravity irrigation system and which would require numerous pump lifts.

The economic effects of crop production costs and net returns are recognized as one of the most influential factors in limiting the seasonal irrigated acreage and resulting water requirements. It is probable that there will always be a tendency to withdraw land from production in years of economic adversity. Inasmuch as the concept of ultimate development, adopted for purposes of the present studies, presupposes maximum land use within physical limitations, economic effects were not given consideration in determining the probable ultimate net irrigated area. This assumption is conservative in relation to water requirements for the estimated requirements for future water resources development have thus been maximized in this stage of planning.

Based on the foregoing factors, it was estimated that the net irrigable area would amount to 158,000 acres of the gross irrigable area of 196,000 acres under ultimate conditions, if sufficient water supplies could be developed.

The projection of a probable ultimate crop pattern that could be sustained on the net irrigable lands in the Upper Feather River Basin was an important step in evaluating ultimate water requirements. The present development of irrigated agriculture throughout California was considered in projecting the ultimate crop pattern. Other factors affecting the ultimate crop pattern are climate and limitations on crop adaptability, due to various undesirable land and soil characteristics revealed by the land classification surveys. The county farm advisors and leaders in agriculture in the basin furnished additional information to aid in the forecast of future agricultural development.

In many areas of the upper basin at higher elevations, irrigable lands occur in valleys surrounded by large tracts of public forest lands. In these areas, beef production has developed largely on the basis of meadow pasture lands in conjunction with forest grazing lands. The public lands provide summer grazing while the irrigated lands provide forage crops for fall and winter feeding. It was assumed that this livestock economy would continue, and, therefore, the crop projection for these areas was weighted heavily toward an increase in irrigated pasture and forage crops.

The crop pattern forecast for the 158,000 acres in the upper basin under conditions of ultimate development was as follows: improved pasture, 72,000 acres; meadow pasture, 41,000 acres; alfalfa, 18,000 acres; grain, 12,000 acres; truck crops, 12,000 acres;and orchards, 3,000 acres. The probably ultimate crop pattern is presented in Table 17.

Urban and Suburban Lands

The ultimate urban water requirement was determined on a population basis. The area of land which is expected to become predominantly urban and suburban in character was determined by Pacific Planning and Research. The estimated acreages for each hydrographic unit are presented in Table 19 as an indication of the extent of lands that may ultimately be devoted to this use.

Forest Lands and Uses

Estimates of areas of commercial forest land and production of timber products were used to compute water requirements for the forest

TABLE 17

PROBABLE ULTIMATE PATTERN OF IRRIGATED LAND USE
IN THE UPPER FEATHER RIVER BASIN

(In acres)

Hydrographic unit		Crop							Total
Reference number	Name	Alfalfa	Pasture: Improved	Pasture: Meadow	Grain and grain hay	Truck	Deciduous orchard	Sub-tropical orchard	ir-rigate area
1	North Fork Feather River	900	9,000	6,600	600	0	800	600	18,500
2	East Branch Feather River	2,200	12,400	8,500	2,000	2,200	1,800	0	29,100
3	Sierra Valley	14,200	41,400	23,400	9,100	9,100	0	0	97,500
4	Middle Fork Feather River	500	8,100	2,800	400	200	200	0	12,200
5	South Fork Feather River	0	600	0	0	0	200	0	800
	TOTALS	17,800	71,500	41,300	12,000	11,800	3,000	600	158,100

products industry. The State Division of Forestry provided information from which the area of commercial forests were obtained. The United States Forest Service at the request of the Department of Water Resources made estimates of sustained annual yield of timber for each of the 15 counties included in the Northeastern Counties Investigation. Based on further information from the United States Forest Service, and the California Forest and Range Experiment Station, the estimates of sustained yield were converted to estimates of annual production of forest products for each county. Estimates of sustained timber yield and production of forest products for the Upper Feather River Basin were made assuming that yield and production would be in proportion to the distribution of commercial forest areas.

The total area of commercial forest within the upper basin has been estimated at about 1,634,000 acres, or about 63 percent of the gross area.

The sustained annual timber yield of these lands was further estimated to be about 431 million board feet measured by the international scale. This yield could be used in the production of about 390 million board feet of lumber (lumber tally) and about 67,000,000 square feet of plywood (3/8-inch basis). Additional logging and mill residue that would probably be shipped to the Sacramento Valley to be used in the production of pulp, fiberboard, and paper products, would not create a water requirement within the Upper Feather River Basin.

The above production quantities were used in making estimates of ultimate water requirements for the forest products industry in the Basin. Table 19 shows data relating to commercial forest area and sustained timber yield for the Upper Feather River Basin.

Recreational Lands and Uses

Historically, the economic activity in the Upper Feather River Basin has been based upon timber, agriculture, mining, and related service industries. In recent years, however, recreational activity has increased rapidly to a position of major importance in the economy of the area.

The recreational industry in the Upper Feather River Basin is still in its infancy. This fact is confirmed by the results of studies conducted by the firm of Pacific Planning and Research and presented in Appendix A of this bulletin. The firm reported that the rate of recreational development from this time forward can be expected to exceed the rate of population growth in the State by a considerable degree.

Pacific Planning and Research delineated potential recreational areas and further separated the areas into broad classifications of high, medium, and low intensity of recreational use. High intensity recreational

TABLE 18

COMMERCIAL FOREST AREA AND SUSTAINED TIMBER
YIELD WITHIN THE UPPER FEATHER RIVER BASIN

Item	Quantity
Commercial forest area, in acres	1,634,000
Sustained annual timber yield, in board feet (International Scale)	431,000,000
Estimated annual production of lumber, in board feet (lumber tally)	389,000,000
Estimated annual production of plywood, in square feet (3/8-inch basis)	66,960,000

use includes lands of prime recreational potential which are accessible by motor vehicle during the entire vacation season. Most future development is expected to occur in these areas. Medium intensity recreational use includes lands of prime recreational value which are not readily accessible by motor vehicles. These areas will be developed to some extent, but their greatest use will probably be for fishing, hunting, hiking, camping, and similar recreational activities. Low intensity recreational areas are lands generally of inferior scenic and topographic qualities, although they may be important for hunting. These classifications of use were selected so that user-days of recreation on these lands could be estimated. The studies indicated that approximately 1,900,000 acres, or over 80 percent of the total area of the basin, has some recreational potential. The estimated acreages of lands included in the various classifications of recreational use are set forth in Table 19.

Water Skiing on Bucks Lake

Reservoir Areas

The estimated average water surface areas of reservoirs within the Upper Feather River Basin, resulting from existing and possible future projects shown in the California Water Plan, is about 70,800 acres, including Oroville Reservoir. The distribution of this total area is presented by hydrographic units in Table 19.

Present and Ultimate Population

At present, the Upper Feather Basin is rather sparsely populated, but the population may be expected to increase many times as California approaches full development. The population in 1956 of the basin, based on estimates made by the State Department of Finance, is about 16,500, while the ultimate population may reach 125,000. At present, about 80 percent of the people are concentrated in the towns of the area, even though the population of these towns is not classified as urban in United States Census reports.

The economy of the area depends primarily upon agriculture, timber production, and maintenance of resort and recreation facilities. There is some seasonal fluctuation in the population, because each of these pursuits is carried on actively in the summer but is curtailed during the winter. In recent years, employment in the timber industry has been reduced by the closing of a number of logging and milling operations. However, it is estimated that there are continuing increases in employment in connection with recreation.

The present urban population of the Upper Feather River Basin is centered primarily in a number of small towns in the high mountain valleys in the eastern portion of the area. These towns serve as shopping centers for the agricultural population and as industrial centers for the timber industries.

TABLE 19

PROBABLE ULTIMATE PATTERN OF URBAN, SUBURBAN, RECREATIONAL LAND USE AND RESERVOIR AREAS IN THE UPPER FEATHER RIVER BASIN

(In acres)

Reference number	Hydrographic unit	Urban and suburban areas	High intensity recreation areas	Medium intensity recreation areas	Low intensity recreation areas	Principal reservoir areas
1	North Fork Feather River	4,000	528,500	10,500	34,500	45,200
2	East Branch Feather River	3,200	456,000	97,900	20,500	12,000
3	Sierra Valley	3,200	158,300	32,600	11,300	2,400
4	Middle Fork Feather River	3,200	370,100	51,300	0	7,500
5	South Fork Feather River	1,600	97,800	0	0	3,700
	TOTALS	15,200	1,610,700	192,300	66,300	70,800

The largest community in Plumas County, Quincy, with a population of about 3,300, is the county seat and serves the surrounding agricultural and timber-producing areas. Portola has a population of about 2,300, while Chester, Greenville and Loyalton have populations of 1,600, 1,200 and 1,000, respectively. There are a number of towns such as Blairsden, Calpine and Sierraville which have populations of only a few hundred. All of these towns provide resort and recreational facilities for tourists. A summary of estimates of the 1956 population is shown in Table 20 for each of the hydrographic units within the Upper Feather River Basin.

Estimates of ultimate population were made for the Department of Water Resources by the firm of Pacific Planning and Research as part of the Northeastern Counties Investigation. Detailed results of these studies are contained in Appendix A, "Future Population, Economic and Recreation Development of California's Northeastern Counties", published in 1957 as part of Bulletin No. 58, "Northeastern Counties Investigation". The population of California, based on full development of all natural resources in the period from 2,020 to 2,050 was estimated to be 56,000,000, and the corresponding ultimate population of the Upper Feather River Basin would be about 125,000. The ultimate population estimates were subdivided into urban and suburban, rural farm and rural non-farm categories. Employment in agriculture, industry and recreation was given consideration in making this subdivision. A summary of the estimated ultimate population for each of the hydrographic units within the Upper Feather River Basin is shown in Table 21.

Water Requirements

The estimates of probable ultimate water requirements in the Upper Feather River Basin are the amounts of water that would be required to meet consumptive uses of applied water and irrecoverable losses incidental to such use. These estimates, modified by appropriate efficiency factors, constitute the quantity of water needed to fully irrigate the ultimate crop pattern set forth in the preceding section of this chapter. Water requirements for irrigated agriculture, combined with water requirements for urban, suburban, industrial and recreational uses were then used as the basis for planning future water development in the basin.

The term "requirement" is a general term that expresses need for beneficial use of water, and it is customary that it be used with certain modifying words which by implication define the exact nature of the requirement. For example, "diversion requirement" is the amount of water needed at the point of diversion on a stream system to provide for losses in conveyance

TABLE 20

ESTIMATED PRESENT (1956) POPULATION BY HYDROGRAPHIC UNITS
WITHIN THE UPPER FEATHER RIVER BASIN

Hydrographic unit: Reference number	Hydrographic unit: Name	Urban	Rural farm	Rural non-farm	Totals
1	North Fork Feather River	1,328	197	3,435	4,960
2	East Branch Feather River	*	171	4,879	5,050
3	Sierra Valley	*	364	1,667	2,031
4	Middle Fork Feather River	*	63	4,356	4,419
5	South Fork Feather River	*	5	0	5
	TOTALS	1,328	800	14,337	16,465

* Urban population is included with rural non-farm.

of water to places of use, for the necessary irrigation head to distribute the water in the fields, for the wetting of the soil volume, and for deep percolation. It takes into account the re-use of return flows from irrigation or other employments of the water. A "service area requirement" accounts for all the foregoing uses of water in a specified service area, measured, however, at the point or points of entrance of the water to the area, or the equivalent, rather than at a point of diversion on a stream system.

Consumptive water requirements refer to the net loss of water in a given area or stream basin occasioned by water utilization. Requirements for water that cause an impairment in the quantity of the water supply remaining available for other purposes are herein referred to as "consumptive requirements." In general, they include irrigation, municipal, and industrial requirements.

TABLE 21

ESTIMATED ULTIMATE POPULATION BY HYDROGRAPHIC UNITS
WITHIN THE UPPER FEATHER RIVER BASIN

Hydrographic unit: Reference number	Hydrographic unit: Name	Urban	Rural farm	Rural non-farm	Totals
1	North Fork Feather River	27,450	450	27,900	55,800
2	East Branch Feather River	8,000	400	16,850	25,250
3	Sierra Valley	4,800	1,450	2,750	9,000
4	Middle Fork Feather River	4,000	250	17,350	21,600
5	South Fork Feather River	3,500	50	9,450	13,000
	TOTALS	47,750	2,600	74,300	124,650

Another major loss of water in the Upper Feather River Basin results from evaporation from reservoir surfaces.

Only a part of the water which is applied to irrigated land is lost to the basin through transpiration by crops and evaporation from the land surfaces that have been artifically wetted. For practical purposes, these two losses of irrigation water, known as "consumptive use", are the only significant physical losses to the total quantity of water in a stream basin. For convenience, similar physical losses caused by other employments of water are also termed "consumptive use", although they may be entirely evaporative in character, such as losses from reservoir surfaces.

Nonsumptive requirements refer to the use of water for fish propagation, power production, or for aesthetic purposes, in which the water is put to beneficial use and then returned to natural channels. In most instances, the regimen of stream flow is affected but not the quantity or quality of the water.

Unit Values of Water Use

Unit values of water use for irrigated lands refer to the consumptive use of applied water by plants and the adjacent soil, expressed in feet of depth. A unit value may also be thought of as a volume in terms of acre-feet per acre. The consumptive use of applied water for a given hydrographic unit was computed as the product of the unit value of water use of the unit and the acreage of land involved.

Ideally, unit values of water use for irrigated agriculture, urban areas, industrial production, and recreational development should be based upon measurements of the quantities of water actually utilized. Such data should be collected for the area under consideration to reflect the varying climatic and operational influences, and the measurements should be extensive enough to reflect season-to-season variations in demand. In the absence of adequate data, it was necessary to use the available water use measurements together with supplementary data relating to physical conditions that affect consumptive use of water. From these data, unit values of water use were estimated.

Analyses of all available water use data were made and tabulated. Extensive studies were initiated to collect new data on water use for irrigated crops, urban and suburban service, the forest products industry, recreational activities and evaporation from reservoir surfaces. Mean seasonal unit values were estimated for each of these types of water use. The values of consumptive use of applied water for irrigated crops were determined by the basic methods set forth and described in Bulletin No. 58.

Unit values of agricultural water use developed in this investigation were based on the assumption that sufficient water would be available at all times to meet the normal demand for water by growing plants. However, those familiar with the operation of water service agencies will recognize that weather, agricultural practices, and economic factors affect the demand for irrigation water and, in turn, affect the amount of water consumptively used from season to season. Estimated mean seasonal unit values of consumptive use of applied water on irrigated lands are presented in Table 22.

TABLE 22

ESTIMATED MEAN SEASONAL UNIT VALUES OF CONSUMPTIVE USE
OF APPLIED WATER ON IRRIGATED LANDS
IN THE UPPER FEATHER RIVER BASIN

(In feet of depth)

Hydrographic unit		Crops						
Reference number	Name	Alfalfa	Improved pasture	Meadow pasture	Grain and grain hay	Truck crops	Deciduous orchards	Subtropical orchards
1	North Fork Feather River	1.8	1.9	2.3	0.3		1.8	1.8
2	East Branch Feather River	1.9	1.9	2.3	0.3	0.9	1.6	
3	Sierra Valley	1.8	1.9	2.3	0.3	0.8		
4	Middle Fork Feather River	1.8	1.9	2.3	0.3	0.8	1.7	
5	South Fork Feather River		1.9	2.3			1.7	

Estimates of unit values of water in present and ultimate urban, and suburban areas were determined on a per capita basic rather than on a unit area basis. The average daily quantity of per capita water use was computed from available records of water delivery and water consumption in urban areas in the mountainous northeastern counties of the State. It was estimated that the present water delivery requirement is about 160 gallons per capita per day for urban and suburban areas, and about 130 gallons per capita per day for rural areas. It was also estimated that, under ultimate conditions, the per capita water requirement would increase to 250 gallons per day for urban and suburban areas, and to 200 gallons per capita per day for rural areas. These values represent water delivered at the point of use. Irrecoverable losses resulting from such use were estimated as 50 percent of the delivery requirement. The unit values used to determine consumptive use and water requirements for domestic purposes in urban, suburban and rural areas are shown in Table 23.

TABLE 23

ESTIMATED UNIT VALUES OF CONSUMPTIVE USE AND WATER REQUIREMENT FOR DOMESTIC PURPOSES IN URBAN, SUBURBAN AND RURAL AREAS

(In gallons per capita per day)

Development	Consumptive use		Water requirement	
	Present	Ultimate	Present	Ultimate
Urban and suburban areas	80	125	160	250
Rural areas	65	100	130	200

Separate estimates were made of potential water use by the forest products industry. The major products of this industry are lumber and plywood. Unit values of water use for these items were obtained from information made available by the United States Forest Service and various private companies, and are shown in Table 24.

TABLE 24

ESTIMATED UNIT VALUES OF CONSUMPTIVE USE AND WATER REQUIREMENT FOR THE FOREST PRODUCTS INDUSTRY WITHIN THE UPPER FEATHER RIVER BASIN

Item	Unit	Consumptive use	Water requirement
Lumber	Gallons per board foot of product	1.0	1.0
Plywood	Gallons per board foot of logs used	1.0	1.0

Estimates of the water requirement to meet recreational demands were based on the number of user-days determined by the firm of Pacific Planning and Research and reported in Appendix A of Bulletin No. 58. The categories comprised permanent and summer residences, commercial resorts and motels, organizational camps, and camping and picnic areas. The unit values of water use, largely estimated from experience and judgment, represent both consumptive use and water requirement, and are shown in Table 25.

TABLE 25

ESTIMATED UNIT VALUES OF CONSUMPTIVE USE OF WATER
FOR RECREATIONAL ACTIVITIES WITHIN THE
UPPER FEATHER RIVER BASIN

(In gallons per user-day)

Type of use	Unit value of consumptive use
Permanent and summer residences	150
Commercial resorts and motels	100
Organizational camps	50
Camping and picnic areas	10

Unit values of net monthly evaporation from reservoir surfaces were estimated as the amount of evaporation in excess of precipitation during those months when evaporation is greater than precipitation. Net seasonal evaporation from reservoir surfaces was derived by the summation of the monthly excess of evaporation over precipitation and was expressed in terms of depth of water. Net reservoir surface evaporation generally occurs during the 7-month period of April through October. For this investigation, gross evaporation from reservoir surfaces was estimated from pan evaporation records and atmometer records. Precipitation records were obtained for reliable stations at or near the locations of evaporation pans or atmometers. Net seasonal evaporation from reservoir surfaces was found to range between 27 inches and 38 inches in the Upper Feather River Basin.

Consumptive Use of Applied Water

Estimates were made of the amount of water consumptively used under present and probable ultimate conditions. In general, these estimates were derived by applying the appropriate unit values of water use to the present and estimated ultimate patterns of land use.

Present Use of Applied Water. Present consumptive use of applied water for irrigated crops, on swamp and marsh lands, and from principal reservoirs was estimated by multiplying the estimated acreage of each class of use by the appropriate unit value of consumptive use of water. Total consumptive use of applied water in urban and rural development was estimated as the product of the population for each category times the appropriate value of per capita water use. The estimate of consumptive use of applied water for present urban and rural purposes includes water usedfor industrial and recreational purposes as well as the forest products industry.

Unit values of consumptive use of applied water for irrigated crops were determined on the basis of a full water supply, sufficient to meet the optimum moisture needs of the crop. However, in many areas full seasonal water supplies are not presently available,and crops are subject to a deficient irrigation supply during summer and fall months. Where this condition exists, the computed consumptive use of applied water was reduced by a factor to indicate actual consumptive use under present water supply conditions. The ratio of actual consumptive use of applied water to optimum consumptive use, expressed as a percentage, was estimated by comparison of developed water supplies to potential consumptive use, and from information furnished by watermasters on availability of water in watermaster service areas. As a result, the present consumptive use of applied irrigation water presented herein is about 45 percent of the amount that would be used if full water supplies were available.

Net evaporation from reservoir water surfaces is considered equivalent to consumptive use of applied water, since it results in a depletion of the available water supply. Net reservoir evaporation represents the quantity of water that is lost to use over and above the amount of water previously consumed on the lands in the reservoir before construction. To derive consumptive use from reservoir surfaces, average areas of reservoir surfaces for each of the hydrographic units were multiplied by unit net seasonal evaporation values.

Estimates of present mean seasonal consumptive use of applied water are presented in Table 26 by hydrographic units. These estimates were based on the existing water supply development in the basin.

TABLE 26

ESTIMATED PRESENT MEAN SEASONAL CONSUMPTIVE USE OF APPLIED WATER IN THE UPPER FEATHER RIVER BASIN

(In acre-feet)

Reference number	Hydrographic Unit	Irrigated lands	Urban and suburban lands	Net reservoir evaporation	Totals
1	North Fork Feather River	13,100	400	67,500	81,000
2	East Branch Feather River	18,500	400	800	19,700
3	Sierra Valley	31,700	100	0	31,800
4	Middle Fork Feather River	7,300	300	400	8,000
5	South Fork Feather River	200	0	200	400
	TOTALS	70,800	1,200	68,900	140,900

Probable Ultimate Consumptive Use of Applied Water. The procedures utilized to estimate probable ultimate consumptive use of applied water were similar to those employed to estimate present consumptive use. The amount of water that would be used on lands ultimately irrigated was estimated by multiplying the forecasted ultimate acreage of each crop type by its respective unit value of consumptive use of applied water. Ultimate seasonal consumptive use of applied water by urban and suburban lands, recreational areas, and forest products industry, and by evaporation from principal reservoirs was estimated as the product of the forecasted level of development times the corresponding unit value of water use.

Estimates of ultimate consumptive use of applied water for irrigated lands are based on the assumption that a full seasonal water supply would be available to the net crop acreage that might ultimately be irrigated in any one season.

Consumptive use of applied water for urban and suburban purposes was computed as the product of the appropriate estimated population and the unit value of per capita water use. Consumptive use of applied water was estimated to be 50 percent of the water requirements. The probable ultimate consumptive use of applied water for forest products industry was estimated by multiplying the estimated annual production of lumber and plywood that would be ultimately processed on a sustained yield basis by the appropriate average unit value of applied water consumed in processing.

The ultimate consumptive use of applied water for recreational purposes was determined by multiplying the estimated user-days for each type of use in the recreation areas by the appropriate unit value of per capita water use. The totals were then expressed in acre-feet per season for each hydrographic unit.

The amount of evaporation from a reservoir surface under ultimate conditions was estimated as the product of the surface area in acres at average operating level times the net seasonal depth of evaporation from the reservoir surface. The reservoirs included in the estimate are the existing reservoirs and those included in the Upper Feather River Basin under the California Water Plan. The estimated amount of evaporation from reservoir surfaces under ultimate conditions is approximately 40 percent of the total consumptive use of applied water in the Upper Feather River Basin.

Estimates of probable ultimate mean seasonal consumptive use of water are presented in Table 27.

TABLE 27

PROBABLE ULTIMATE MEAN SEASONAL
CONSUMPTIVE USE OF WATER
WITHIN THE UPPER FEATHER RIVER BASIN

(In acre-feet)

Reference number	Hydrographic unit	Irrigated lands	Urban and suburban lands	Forest products industry	Recreational areas	Net reservoir evaporation	Totals
1	North Fork Feather River	36,600	5,200	600	4,500	143,900	190,800
2	East Branch Feather River	52,800	2,000	200	3,500	27,300	85,800
3	Sierra Valley	168,300	1,400	100	1,200	5,400	176,400
4	Middle Fork Feather River	23,400	3,400	200	3,300	19,000	49,300
5	South Fork Feather River	1,500	2,500	100	1,100	8,900	14,100
	TOTALS	282,600	14,500	1,200	13,600	204,500	516,400

Probable Ultimate Water Requirements

A determination was made of the probable ultimate requirements for water in the area under investigation. This estimate represents the gross amount of water required to meet both demands for consumptive use of applied water and irrecoverable losses incidental to its application. Consideration was given to both farm irrigation efficiencies and the re-use of return flow from water applied within the hydrographic unit. This estimate is the measure of the required water supply that ultimately should be developed on a firm basis for the particular hydrographic unit. In general, the estimates of water requirements were derived by dividing the consumptive use of applied water by an appropriate water service area efficiency factor for the particular hydrographic unit.

The various water requirements are considered and evaluated separately for irrigated agriculture, urban and suburban lands, the forest products industry, recreational areas and evaporation from reservoir areas. The estimates of probable ultimate mean seasonal water requirements to meet consumptive demands are summarized in Table 28.

TABLE 28

PROBABLE ULTIMATE MEAN SEASONAL WATER REQUIREMENTS WITHIN THE UPPER FEATHER RIVER BASIN

(In acre-feet)

Reference number	Hydrographic unit	Irrigated lands	Urban and suburban lands	Forest products industry	Recreation areas	Net reservoir evaporation	Totals
1	North Fork Feather River	73,100	10,500	600	4,500	143,900	222,600
2	East Branch Feather River	70,300	4,000	200	3,500	27,300	105,300
3	Sierra Valley	210,400	2,800	100	1,200	5,400	219,900
4	Middle Fork Feather River	34,200	6,800	200	3,300	19,000	63,500
5	South Fork Feather River	3,000	5,100	100	1,100	8,900	18,200
	TOTALS	391,000	29,200	1,200	13,600	204,500	639,500

CHAPTER VI. PLANS FOR WATER DEVELOPMENT

The growth and enhancement of the economy of the Upper Feather River Basin will require the further development of water resources to provide for local needs. In the Indian Valley, Upper Indian Creek, and Sierra Valley areas, the allocation of the unregulated water supplies to meet current demands has been accomplished by water right adjudication and watermaster service. In these areas, however, optimum returns from presently irrigated lands, as well as desirable expansion of irrigation to lands not now served, are impeded by the insufficiency of summer and fall water supplies. Also, in the Upper Indian Creek, Spanish Creek, Big Grizzly Creek, and Middle Fork, and South Fork of the Feather River Basins, enhancement of the large recreational potential and further production of hydroelectric power would require new water conservation developments.

In most hydrographic units of the Upper Feather River Basin, large surplus flows of water are available during the snowmelt period of every season. These surplus flows, if properly controlled and regulated, would, in most cases, more than meet the ultimate water requirements of the units. The principal exception to this situation is Sierra Valley where there is insufficient water available to meet water requirements for full developments of all irrigable land. However, in general, large surplus flows would be available for export to water-deficient areas in other parts of California after probable ultimate water requirements of the Upper Feather River Basin have been met.

As previously stated in Chapter II, individual plans for developing the waters of the Upper Feather River Basin were conceived as part of a basin-wide master plan. Under this master plan, the waters of the basin would be developed for all beneficial purposes to obtain maximum net benefits. Primary consideration was given, however, to developments that would provide water to meet consumptive use in the Upper Feather River Basin. Incidental to the development of plans which would satisfy these requirements, consideration was given to projects which would develop hydroelectric power and provide water for water-deficient areas in the Sacramento Valley.

In this chapter, general features and estimates of costs and benefits of projects considered for development in the Upper Feather River Basin are set forth. Geology as it pertains to proposed dams, reservoirs, and related water development facilities is presented where each of these facilities is discussed. The proposed projects are presented under the general headings of "Plans for Water Development of the Middle Fork Basin", "Alternative Plans for Development of the Middle Fork of the Feather River below Sierra Valley", "Plans for development of North Fork of the Feather River", and "The South Fork Project on the South Fork of the Feather River".

Plans for Water Development of the Middle Fork Basin

The water resources of the Middle Fork Basin are essentially undeveloped, even though numerous possibilities exist for storage of unregulated waters for irrigation use, enhancement of fishing and recreation, flood control, and the production of hydroelectric power.

In the following discussion, plans are presented for three possible projects which could supply water to meet local needs in Sierra Valley. Two of the projects, Frenchman and Grizzly Valley, were authorized by the Legislature in 1957 as part of the Feather River and Delta Diversion Projects. The other potential project, Sheep Camp, was studied as a possible future development. Plans for these projects are delineated on Plate 6, entitled "Projects for Supplying Water to Upper Feather River Basin".

Sierra Valley Service Area

Sierra Valley is a mountain valley located in the Middle Fork of the Feather River in the southeastern portion of Plumas County and the northeastern portion of Sierra County. The valley comprises about 118,000 acres, of which about 97,500 acres are irrigable.

The climate of Sierra Valley is characterized by its aridity. The average seasonal depth of precipitation on the valley floor is only about 15 inches and is less than 10 inches on a part of the valley. Other major climatic characteristics are an abundance of sunshine, wide range of temperature, low humidity, and high rate of evaporation. More than 90 percent of the total seasonal precipitation normally occurs between the first of October and the last of May; about one-half of which is in the form of snow.

The elevation of the valley floor is approximately 4,900 feet. Consequently, below freezing temperatures can occur during any month of the year.

Winters are moderately severe, with monthly minimum temperatures remaining below freezing during the period from November through March. Snow on the valley floor begins to melt about the first of March, while on the surrounding mountains snow begins to melt about the middle of March. In seasons when heavy snowfall is experienced in the mountains, considerable flood damage occurs to downstream ranches, roads, and other improvements. The snowmelt runoff declines rapidly, and intermittent streams flowing into the valley are generally dry by May 15. Nearly all perennial streams approach minimum flows by June 15.

In general, most of the irrigable lands in Sierra Valley are suited to medium- and shallow-rooted, climatically adapted crops and to a lesser extent are suited to alfalfa, where soil depth permits.

The growing season in Sierra Valley for climatically adapted crops is approximately 90 days. This short growing season, coupled with cool nights, results in relatively low crop yields.

Agriculture in Sierra Valley is dominated by beef cattle production. The major portion of the valley is used for range pasture in its natural state, with an estimated average carrying capacity of 12 acres per mature animal for the period of May through October.

Irrigation is of importance in the maturation and successful production of crops in Sierra Valley. Natural meadows are located in proximity to the small creeks flowing onto and across the valley floor. When natural runoff is available, the meadow lands are irrigated by wild flooding methods by constructing small check dams on the creeks to cause the stream flow to spread out over the land. The lands produce a relatively high-quality hay for winter feeding, with an estimated average yield of about one ton per acre. In the more sheltered portions of the valley, however, alfalfa and domestic grasses have replaced the native grasses as a source of hay and green forage. Some dry grain and grain hay are produced, but the lack of water during the growing season results in rather poor yields.

A total of seven communities, ranging in size from less than 50 to about 2,000 residents, located in and around Sierra Valley. Four of these, Vinton, Beckwourth, Loyalton, and Calpine, are located in the Sierra Valley service area. A fifth community, Portola, located along the Middle Fork of the Feather River several miles downstream from the outlet of the valley, would receive major secondary benefits from the construction of the projects. It is estimated that in the Sierra Valley service area there are about 1,500 inhabitants.

An excellent transportation system traverses Sierra Valley. A major east-west highway, U. S. Highway 40 Alternate, and the main line of the Western Pacific Railroad extend across the north side of the valley. State Highway 89 enters the western portion of the valley from the southeast and extends to Calpine where it leaves the valley to connect with U. S. Highway 40 Alternate at Blairsden. State Highway No. 49 extends from Sierraville through Loyalton to connect with U. S. Highway 40 Alternate at Vinton. Several secondary roads of varying capacity and condition provide access to the surrounding area.

Regulation of the available water supply is urgently needed in Sierra Valley. Runoff from the streams entering the valley floor consists largely of melting snow and comes as torrential floods in the spring and drops sharply soon thereafter. The high spring runoff spreads out over the valley floor, causing flood damage. In contrast to the frequent spring flooding, most of the land has an inadequate water supply during the late summer and early fall months. Because of this water shortage, thousands of acres of farm land produce only part of their potential. Other lands, capable of sustained crop production, are still in sagebrush for lack of water. This shortage of water for irrigation use, particularly during the late irrigation season, makes it essential that supplemental water supplies be developed if the potential of the valley is to be fulfilled.

Full irrigation development of the 97,500 acres of irrigable land in the valley would require about 210,400 acre-feet of applied water seasonally. The estimated seasonal consumptive use that would result from this application is about 168,300 acre-feet. The average seasonal inflow from the streams entering the valley is estimated to be about 155,000 acre-feet. It is indicated, therefore, that there is insufficient water available for full development of all the irrigable land in the valley. A more detailed discussion of water utilization and requirements is presented in Chapter V.

The development of water resources for Sierra Valley would provide an opportunity for enhancement of the outdoor recreational potential. Sierra Valley is located in an attractive recreational area and the construction of reservoirs and regulation of stream flow would aid in satisfying future recreational demand.

Authorized Projects

In February 1957, the Department of Water Resources issued Bulletin No. 59, an interim report on the Upper Feather River Basin Investigation, entitled "Interim Report on Engineering, Economic, and Financial Feasibility of Initial Units". Bulletin No. 59 presents data on three proposed projects of which two, Frenchman and Grizzly Valley, are located on the Middle Fork of the Feather River, and the third, the Indian Creek Recreation Project, is located on the North Fork. Following the publication of the bulletin, the Legislature authorized the three projects as the initial units of the Upper Feather River Division of the Feather River and Delta Diversion Projects.

Frenchman Project. Frenchman Project consists of a dam and storage reservoir and system of works that will regulate the waters of Little Last Chance Creek a tributary to Sierra Valley. The project will provide water for irrigation use, result in partial flood control to downstream areas, and furnish the basis for enhancement of recreational opportunities. Its operation will provide a regulated water supply of about 15,000 acre-feet seasonally, of which a large part will be new water. In addition, regulation of the presently

Frenchman Dam Under Construction

available unregulated water supply will enable more effective use of the water over a longer period during the irrigation season.

The project will provide incidental flood control benefits. In the operation studies of Frenchman Reservoir, no specific reservation of storage space was made for flood control purposes. Storage space above the ungated spillway crest, however, would provide a high degree of flood protection by reducing flood peaks on Little Last Chance Creek. It was estimated that the once-in-100 year flood peak will be reduced from 4,400 second-feet to about 1,300 second-feet, a flow that will cause negligible damage.

The reservoir will enhance the recreational potential of the surrounding area by providing a setting for the building of camp sites, boating facilities, and summer homes. Both the area adjacent to the reservoir site and the canyon area downstream are attractive for this type of development.

The service area for the Frenchman Project lies within the boundaries of the Last Chance Water District, and comprises those lands now served by diversion of the unregulated flows of Little Last Chance Creek.

The project will consist of a dam and reservoir, basic public recreational facilities, and access roads. The dam is located on Little Last Chance Creek, about one mile downstream from its confluence with Frenchman Creek. The reservoir will have gross storage capacity of 51,000 acre-feet and net storage capacity of 49,300 acre-feet. The water surface area at spillway crest will be about 1,470 acres. The normal pool elevation in the reservoir will be 5,588 feet. The dam will have a height of 130 feet above stream bed, a crest length of 720 feet, and will be constructed of homogeneous earthfill.

Construction of Frenchman Dam and Reservoir was initiated in the fall of 1959. These features will cost approximately $2,210,000. The location of the Frenchman Project and its service area is shown on Plate 6.

Grizzly Valley Project. The authorized Grizzly Valley Project would consist of a dam and storage reservoir that would regulate the waters of Big Grizzly Creek, and a conduit extending to the proposed service area in Sierra Valley. The project would provide water for irrigation use, and furnish the basis for the enhancement of recreation opportunities. Its operation would provide a regulated water supply of about 15,100 acre-feet seasonally, of which 14,900 acre-feet would be new water that presently is unavailable to irrigators in Sierra Valley.

The proposed reservoir would enhance recreational opportunities by providing a setting for the building of camp sites, boating facilities, and summer homes. Both the area surrounding the reservoir and the area downstream are desirable for this type of development.

Although the reservoir would reduce the peak of floods of Big Grizzly Creek, flood control benefits from the project would be insignificant since very little flood damage occurs to downstream property under present conditions.

The service area for the proposed Grizzly Valley Project lies partly within the boundaries of the existing Last Chance Creek Water District and partly in the portion of Sierra Valley lying immediately north of the district. Operation of the project would be integrated, therefore, with the operation of the Frenchman Project. As a result approximately 6,200 acres, in addition to those served by the Frenchman Project would receive a full irrigation supply.

The Grizzly Valley Project would consist of a dam and reservoir on Big Grizzly Creek, about five miles north of Portola; a conveyance system to deliver water to Sierra Valley; and basic recreational facilities and necessary access roads. The reservoir would have a gross storage capacity of 80,000 acre-feet, and a net storage capacity of 77,800 acre-feet. The water surface area at spillway crest would be 4,100 acres, and the normal pool elevation in the reservoir would be 5,775 feet. The dam would have a height of 123 feet above stream bed, a crest length of 380 feet, and it would be constructed of earthfill.

Preliminary data on the estimated costs of the authorized Grizzly Valley Project and on the benefits that would accrue therefrom were presented in Bulletin No. 59. The department is currently engaged in advanced planning studies which include a re-evaluation of the costs and accomplishments of the project.

Location of the Grizzly Valley Project and its service area is shown on Plate 6.

Sheep Camp Project

The Sheep Camp Project would include the construction of a dam and reservoir on Carman Creek about two miles north of Calpine. Water from nine small watersheds that drain onto the valley floor would be intercepted by a canal extending northwesterly across Sierra Valley to a pumping plant located at the base of Sheep Camp Dam. This water would be pumped into the proposed reservoir for storage and later release during the irrigation season to the intercepting canal for conveyance to lands located below the canal. The location of the proposed Sheep Camp Project is shown on Plate 6.

The proposed Sheep Camp Project would provide a regulated water supply of about 48,000 acre-feet seasonally, of which 25,000 acre-feet would be new water that presently is unavailable to irrigators in the valley. In addition, the presently available unregulated water supply could be more effectively used over the irrigation season than at present.

About 20,000 acres located below the intercepting canal could be served from Sheep Camp Project, exclusive of the proposed service areas for the authorized Grizzly Valley and Frenchman Projects. The total seasonal yield from Sheep Camp Reservoir could meet the water requirements for this area, which amount to about 48,000 acre-feet per season.

The reservoir could result in the enhancement of an outdoor recreational area by providing a setting for the building of camp sites, boating facilities, and summer homes.

The reservoir would be located near the western edge of Sierra Valley and would lie in both Sierra and Plumas Counties. It would inundate Carman Valley and have a storage capacity of 65,000 acre-feet at normal pool and a minimum storage capacity of 5,500 acre-feet. The water surface area would be 1,635 acres at spillway crest elevation of 4,997 feet, and 640 acres at minimum pool elevation.

A topographic map of the reservoir area was prepared in 1956 to a scale of one inch equals 400 feet and with a contour interval of five feet. Reservoir storage capacity and water surface area data for various pool elevations at Sheep Camp Reservoir were determined from this map and are presented in Table 29.

TABLE 29

AREAS AND CAPACITIES OF SHEEP CAMP RESERVOIR

Depth of water at dam, in feet	Water surface elevation, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	4,925	0	0
15	4,940	370	2,100
25	4,950	720	7,700
35	4,960	970	16,300
45	4,970	1,170	27,000
55	4,980	1,350	39,600
65	4,990	1,520	53,900
72	4,997	1,635	65,000
75	5,000	1,690	70,000

Preliminary geologic investigation of the Sheep Camp Project was accomplished during 1956 and 1957. The exploration program included surface geologic mapping of the main dam and auxiliary dam sites, reservoir area, potential borrow areas, and intercepting canal route; drilling and sampling of materials from 22 test holes along the axes of the proposed dams and spillway; dozer excavation of test trenches on the abutments of the main dam; seismic exploration along the axis of the main dam to determine depth to bedrock and the extent of a compact plastic clay bed in the channel section; and collection of soil samples and estimation of quantities to determine the suitability and availability of potential borrow materials.

The main dam site at Sheep Camp is situated across the broad flat valley of Carman Creek adjacent to Sierra Valley. Bedrock on the abutments consists of jointed granitic rock that, in places, is weathered deeply. The upper part of the left abutment consists of volcanic rock, mainly andesite. Volcanic rock caps most ridges and hills in the area. The channel is filled with recent alluvium and lake sediments to a depth of at least 150 feet at the deepest point. The granitic bedrock on the left abutment slopes gently under the channel fill toward the right abutment. Along the right abutment, a normal fault has dropped the granitic bedrock surface in the channel relative to the abutment. Jointing in the granitic rock on the abutments is moderate, and most of the joints appear tight.

The results of the drilling indicate a nearly continuous impervious clay stratum in the channel at a depth of about 18 feet. The plastic nature of the clay stratum and the unconsolidated nature of the channel material present serious foundation problems. Extreme care in the design and construction of a dam on this site would be required.

Stripping to a depth of about 18 feet beneath the pervious section would intercept the nearly continuous impervious clay stratum and would insure cutoff. An average stripping depth of about 30 feet of disintegrated granitic rock on the right abutment would be required to reach competent bedrock. On the left abutment the removal of about 10 feet of disintegrated granite and loose volcanic material beneath the impervious section of the dam should be adequate. Heavy grouting would be required in the volcanic rocks on the left abutment. Difficulty may be experienced in grouting the weathered granitic rock along the volcanic-granitic contact.

The spillway would be located along the upper portion of the left abutment and would need lining, as the rock is deeply weathered.

Two auxiliary dams would be required. One auxiliary dam site is located about 0.5 mile northeast of the main dam, and the other is approximately two miles northeast of the main dam. Geologic conditions at the site about 0.5 mile from the main dam are similar to those of the left abutment of the main dam. The other auxiliary dam site located about two miles northeasterly of the main axis would require a dam about 27 feet in height. The foundation rock at this site is suitable for a dam of the proposed height.

Volcanic rock outcrops along the uppermost part of the abutments. On the lower portions of the abutments, bedrock is masked by slope wash. The channel contains an impervious slope wash fill to a depth of about six feet. Volcanic tuff and agglomerate underlie the slope wash. The lower left abutment is underlain by loose granitic sand, which is believed to be a beach deposit from an ancient lake. Stripping beneath the impervious section of the auxiliary dam would total three to five feet. An impervious blanket across the lower left abutment, where loose beach sand occurs, may be necessary to provide cutoff.

Seismicity in the region of Sheep Camp dam site is regarded as moderate to high. Borrow material is considered adequate in quantity and quality. Decomposed granitic rock located adjacent to the right abutment is a source of impervious material. Nearby outcropping granitic rock could be quarried for riprap. Based on the preliminary program of exploration, an earthfill dam with a height of up to 100 feet could be built at the Sheep Camp site. Geologic conditions of Sheep Camp dam site are shown on Plate 7.

It was estimated that the average seasonal runoff from the 89 square miles of drainage area above the intercepting canal is about 46,000 acre-feet. In addition, the estimated average seasonal runoff of Carman Creek from the 23 square miles of watershed above Sheep Camp dam site is about 13,000 acre-feet.

Monthly yield studies were conducted in sizing the Sheep Camp Project. From the studies, a reservoir storage capacity of 65,000 acre-feet was selected to illustrate the accomplishments of the project. Releases from the reservoir were assumed to meet an irrigation demand schedule. A summary of the yield study for the reservoir is presented in Appendix B, entitled "Summary of Project Yield Studies".

The dam would be of earthfill construction with a height of 82 feet and a crest length of 3,300 feet. The choice of dam section was influenced by the serious foundation weakness. The dam would consist of a homogeneous embankment with a 3.25 to 1 upstream slope and 2 to 1 downstream slope. Berms with a width of 200 feet would be located on both slopes at an elevation 36 feet below the crest of the dam.

Two auxiliary dams with heights of 27 feet would be constructed in saddles located northeasterly of the main dam. Embankment slopes of these dams would be 3.5 to 1 upstream and 3 to 1 downstream.

A concrete-lined spillway would be located in the left abutment of the dam. A concrete ogee weir would discharge into a constant width, rectangular, concrete-lined chute extending across the andesitic mud flow of the abutment to a point where the mud flow contacts granitic rock. From this point to the stream bed, the chute would be unlined. At maximum water surface elevation of 5,000.5 feet, the spillway discharge would be 1,000 second-feet, the requirement for a standard project design flood, and the surcharge capacity would be 5,500 acre-feet.

The outlet-inlet works would serve both to discharge irrigation releases from the reservoir and to convey water into the reservoir from the pumping plant. A concrete intake structure in the reservoir containing an emergency slide gate would be connected to a 54-inch diameter outlet conduit. The conduit would be a concrete cut and cover section located in a trench on the left abutment. Downstream from the dam, the conduit would be formed of precast concrete pipe. The outlet works would comprise a Howell-Bunger valve located in a concrete valve house and would discharge through a stilling basin to the intercepting canal.

The pumping plant would be located adjacent to both the outlet works and the intercepting canal. Ten pumps arranged in parallel would lift water from a sump located in the canal through a manifold to the inlet-outlet conduit and thence into the reservoir. Each pump would have a capacity of 12,000 gallons per minute at design head.

The intercepting canal would have a capacity of 300 second-feet and would extend in a northwesterly direction across Sierra Valley to intercept the streams which flow in a northeasterly direction through the valley. When water in excess of irrigation requirements is available, it would be pumped from the canal to Sheep Camp Reservoir for storage. During the latter part of the irrigation season, stream flow would be supplemented by releases from the reservoir into the canal. At three major stream crossings the canal would be provided with gated control structures. These structures would control releases from the canal to the downstream channels for irrigation purposes and also would pass stream flows in excess of the canal diversion capacity during flood periods. The canal would be trapezoidal in section and unlined except at the control structures. Spoil from the canal excavation would be placed on the north side of the canal in order to divert overbank flood waters to the control structures. General features of the Sheep Camp Project and related data are presented in Table 30.

A comparison of benefits and costs of the Sheep Camp Project was made to determine the economic justification of the project. The capital cost of the Sheep Camp Project was estimated to be about $5,806,000. The corresponding annual cost, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, plus costs of operation, maintenance and replacement was estimated to be about $415,000. An estimate of the cost of individual project features is presented in Appendix C. A summary of capital and annual costs for the project is presented in Table 31.

Irrigation benefits from Sheep Camp Project would be derived from a new irrigation supply for Sierra Valley and from reregulation of the existing

TABLE 30

GENERAL FEATURES OF SHEEP CAMP PROJECT

Dam Site	
Location	Sec. 5 & 8, T21N, R14E, MDB&M
Stream	Carman Creek
Dam and Appurtenant Features	
Type of dam	homogeneous earthfill
Crest elevation, in feet	5,007
Crest length, in feet	3,300
Crest width, in feet	25
Height above stream bed, in feet	82
Freeboard above spillway crest, in feet	10
Side slopes of main dam	
Upstream	3.25:1
Downstream	2:1
Elevation of stream bed, in feet	4,925
Volume of fill, in cubic yards	2,596,500
Type of spillway	ogee weir with trapezoidal chute
Spillway discharge capacity, in second-feet	1,000
Type of outlet-inlet works	reinforced concrete cut-and-cover conduit under dam, concrete pipe downstream from dam
Reservoir	
Water surface elevation at normal pool, in feet	4,997
Surface area at spillway lip, in acres	1,635
Storage capacity at spillway lip, in acre-feet	65,000
Drainage area, in square miles	23
Seasonal new yield of water, in acre-feet	25,000
Canal	
Type	unlined, trapezoidal section
Length, in feet	25,250
Bottom width, in feet	26.0
Side slopes	2:1
Capacity, in second-feet	300
Pumping Plant	
Number of pumps	10
Capacity per pump, in gallons per minute	12,000
Average annual energy consumed, in kilowatt-hours	1,670,000

TABLE 31

SUMMARY OF ESTIMATED COSTS OF SHEEP CAMP PROJECT

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$ 4,350,000
Lands, easements, and rights of way	133,000
Subtotal	$ 4,483,000
Engineering and administration	448,000
Contingencies	672,000
Interest during construction	203,000
TOTAL CAPITAL COST	$ 5,806,000
ANNUAL COST	
Reservoirs, conveyance, and power features	
Interest and capital recovery	$ 270,000
Operation and maintenance, replacement, general expense, and insurance	70,000
Electrical energy, pumping	39,000
Subtotal	$ 379,000
Recreation features	
Public facilities, including operation and maintenance	$ 36,000
TOTAL ANNUAL COST	$ 415,000

supply. The annual, direct irrigation benefits from the new and reregulated water supply, based on prices and costs during the period 1952-56, were estimated at $209,000 annually.

Recreation benefits would accrue to the Sheep Camp Project from enhancement of the reservoir area. Only those benefits derived directly from public recreational facilities were evaluated for this study. On this basis, the average annual primary benefits from recreation would be $122,000. An evaluation of recreational benefits that would accrue to the Sheep Camp Project is presented in Appendix A.

Some minor flood control benefits would result from operation of the reservoir, even though specific flood control features were not included. However, these incidental benefits were not evaluated and economic justification was based solely on irrigation and recreational benefits.

Total estimated primary benefits from all sources are summarized in Table 32.

TABLE 32

ESTIMATED AVERAGE ANNUAL NET BENEFITS
FROM SHEEP CAMP PROJECT

Item	Benefits
Irrigation	$209,000
Recreation (public facilities)	122,000
TOTAL	$331,000

The resulting ratio of benefits to costs for the Sheep Camp Project would be 0.8 to 1.0 (1959).

Alternative Plans for Development of the Middle Fork of the Feather River below Sierra Valley

Studies were made of six alternative plans for developing the waters of the Middle Fork of the Feather River. These alternatives are the Richvale Plan, Modified Richvale Plan, Clio-Nelson Point-Swayne Plan, Nelson Point-Meadow Valley-North Fork Plan, Nelson Point-Meadow Valley-Bald Rock Plan, and the Turntable-Meadow Valley-Swayne Plan. Although the projects under these alternative plans would be operated primarily to produce hydroelectric power, they also would produce new water for use in areas outside the Upper Feather River Basin as well as to enhance the recreational potential of the basin.

Studies of the alternative plans were conducted for the purpose of determining and comparing estimated costs and accomplishments of each,and were limited to a preliminary determination of engineering feasibility and economic justification. It is noted, however, that because of the necessity for reserving water for upstream use, no monetary evaluation was made of the Richvale Plan. In determining the water supply available for regulation under each alternative plan, it was assumed that the present water supplies of the Middle Fork of the Feather River would be modified by operation of the upstream Frenchman, Grizzly Valley, and Sheep Camp Reservoirs, and by additional ground water development in Sierra and Mohawk Valleys and other smaller valleys. It was estimated that this modification would reduce the present flows of the Middle Fork by an average seasonal amount of about 66,000 acre-feet.

In conducting reservoir operation studies, it was assumed that for stream flow maintenance for fish and wildlife, there would be made a release of 20 second-feet from Clio Reservoir to the Middle Fork of the Feather River, 75 second-feet from all reservoirs located downstream from Sloat, and 10 second-feet from Meadow Valley Reservoir to Spanish Creek. These assumed flows are subject to review by the Department of Fish and Game are are discussed herein in Appendix D.

An evaluation was made to determine the new firm irrigation yield that would be realized from the operation of the alternative Middle Fork Projects. Under the Delta Pooling Concept whereby Oroville Reservoir would be operated as an export project, the alternative Middle Fork Projects were operated disregarding the probable existence of Oroville Reservoir. The yield of new water on a firm irrigation demand schedule for each alternative was estimated as the difference in stream flow at Oroville during the irrigation season, with and without an alternative Middle Fork Project.

An evaluation was made of the probable effect of each alternative plan on the operation of the proposed Oroville Reservoir. This evaluation consisted of operating Oroville Reservoir both with and without the upstream projects to determine the net effect of each project on power output and yield of water. In conducting operation studies of Oroville Reservoir, it was assumed that the following potential upstream projects were constructed and in operation: Frenchman, Grizzly Valley, and Sheep Camp Irrigation Projects; Indian Creek Recreation Project; Squaw Queen Power Project, and Oroville Wyandotte-Yuba County South Fork Project. From these studies it was determined that no additional dependable capacity of the Oroville power plants, over and above that which would be obtained from the pumped storage operation proposed for Oroville Reservoir, would be realized from operation of the alternative Middle Fork Projects.

Richvale Plan

A plan for developing the hydroelectric power potential of the Middle Fork of the Feather River has been advanced by the Richvale Irrigation District. This plan would include the construction of Grizzly Valley Dam and Reservoir on Big Grizzly Creek; an enlargement of Gold Lake; Clio and Nelson Point Dams and Reservoirs on the Middle Fork of the Feather River; and a series of diversion dams, tunnels, and power plants in the canyon of the Middle Fork downstream from Nelson Point. The location of the Richvale Plan is shown on Plate 8, entitled "Alternative Middle Fork Plans, Richvale Plan, and Nelson Point-Meadow Valley-North Fork Plan".

The Richvale Irrigation District has completed its application with the State Water Rights Board for a water right permit for this project. The application has been advertised and protests have been received. Subsequent to the filing of its applications for a water right permit, the District has made some changes in features of the Richvale Plan. The revised projects and its accomplishments as claimed by the district are described herein.

Since the operating criteria utilized by the district to evaluate its plan were substantially different from the criteria adopted by the department in evaluating the other five alternative Middle Fork Projects the department did not fully analyze the Richvale Plan. The primary differences are summarized in the following discussion.

The Richvale District based its studies on full use of the water supplies made available by the upstream reservoirs without stream flow impairment due to irrigation for the first 20 years of project operation. For the period thereafter, the district allowed an average seasonal stream flow depletion of 66,000 acre-feet, for local uses in Sierra Valley and other upstream areas. The district plan would utilize Grizzly Valley Reservoir for upstream storage for release to downstream plants on a power demand schedule for the first 20 years, and for irrigation of land in Sutter and Butte Counties. The department's studies considered that Grizzly Valley Reservoir was a feature of the authorized State Water Resources Development System and would provide an irrigation water supply for use in Sierra Valley as and when needed. Furthermore, the department's studies considered that the alternative Middle Fork

Projects would be operated with a substantial seasonal depletion in water supply resulting from future upstream development and increased water use in larger amounts than assumed by the District.

The district's plan would provide an average summer release of 40 to 50 second-feet for the maintenance of stream flow in the Middle Fork of the Feather River. The department's studies of alternative plans would provide a release of 75 second-feet for the maintenance of stream flow. Actual releases would be worked out jointly with the Department of Fish and Game.

Under the plan of development presently proposed by the district, as recently described to the department and which differs somewhat from the application for a water right permit, Grizzly Valley Reservoir, with a storage capacity of 40,600 acre-feet, would be created by construction of a dam on Big Grizzly Creek about five miles north of Portola, in Section 1, T23N, R13E, MDB&M. Additional storage capacity of 15,910 acre-feet would be provided in Gold Lake on Frazier Creek by increasing the height of the dam at Gold Lake. The regulated waters of Grizzly Valley Reservoir and Gold Lake would be released to flow downstream for reregulation in Clio Reservoir.

Clio Reservoir, with a storage capacity of 156,400 acre-feet, would be created by construction of a dam on the Middle Fork of the Feather River about one-half mile below Clio, in Sections 23 and 26, T22N, R12E, MDB&M. The regulated water from Clio Reservoir would be released for reregulation in Nelson Point Reservoir. Nelson Point Reservoir, with a storage capacity of 116,000 acre-feet, would be created by construction of a dam on the Middle Fork of the Feather River about three miles downstream from the junction of Nelson Creek with the Middle Fork, in Section 18, T23N, R10E, MDB&M. The regulated flow from Nelson Point Reservoir would be released through a tunnel 0.35 mile in length and discharged through Power Plant No. 1. This plant would be located in Section 13, T23N, R9E, MDB&M and would have an installed power capacity of 20,000 kilowatts. Minerva Dam, located in Sections 13 and 24, T23N, R9E, MDB&M, would be constructed to form a reregulating reservoir below Power Plant No. 1. From Minerva Dam, a tunnel 6.1 miles in length would extend to Power Plant No. 2. This plant would be located at Sherman Bar, in Section 36, T23N, R8E, MDB&M, and would have an installed power capacity of 40,000 kilowatts. Dogwood Dam would be constructed to form a reregulating reservoir below Power Plant No. 2 and would be located just below the junction of Dogwood Creek and the Middle Fork of Feather River, in Section 2, T22N, R8E, MDB&M. From Dogwood Dam, a tunnel 5.98 miles in length would convey the water to Power Plant No. 3, which would have an installed power capacity of 40,000 kilowatts, and would be located at Hartman Bar, in Section 11, T22N, R7E, MDB&M. Hartman Bar Dam would be constructed to form a reregulating reservoir below Power Plant No. 3. This dam would be 0.4 mile downstream from the junction of Willow Creek and the Middle Fork, in Section 11, T22N, R7E, MDB&M. From Hartman Bar Dam, a tunnel 7.7 miles in length would convey the water for discharge through Power Plant No. 4. This plant, with an installed power capacity of 50,000 kilowatts, would be located at Milsap Bar, in Section 2, T21N, R6E, MDB&M. Bald Rock Dam, located about one-half mile downstream from American Bar, in Sections 10, 11, and 14, T21N, R6E, MDB&M, would be constructed to form a reregulating reservoir below Power Plant No. 4. From Bald Rock Dam, a tunnel three miles in length would extend to Power Plant No. 5. This plant, with an installed power capacity of 70,000 kilowatts, would be located at the junction of Fall River and the Middle Fork of the Feather River, in Sections 34 and 35, T21N, R6E, MDB&M. The project as described would have a total installed power capacity of 220,000 kilowatts.

The Richvale Irrigation District has estimated that the Richvale Project would make new water available on a firm irrigation demand schedule in the amount of 96,000 acre-feet seasonally. Furthermore, the district claims the project would have a dependable capacity of 210,000 kilowatts and would produce 1,085,000,000 kilowatt-hours of energy seasonally (41 percent of capacity) during the first 20 years of the operation of the project and 970,000,000 kilowatt hours of energy seasonally (34 percent of capacity) during the next 25 years.

The district estimated that the annual hydroelectric power benefits from the project would be $7,336,350 during the first 20 years of project operation and $7,022,400 during the next 25 years.

Irrigation benefits from the Richvale Project were balanced against the cost of proposed irrigation facility improvements which were excluded from the estimates of capital cost. No evaluation by the district was made of the recreational benefits that would accrue to the Richvale Project.

The capital cost of the Richvale Project was estimated to be about $120,000,000. Corresponding annual costs using an interest rate of 4.0 percent were estimated to be $6,991,000. Annual costs using an interest rate of 4.25 per percent were estimated to be $7,228,000.

From information supplied by the Richvale Irrigation District, the benefit-cost ratio of the Richvale Project, based only on benefits from the production of hydroelectric energy, would be about 1 to 1.

Modified Richvale Plan

A Richvale Plan modified by the Department of Water Resources, in which certain changes were made in the size of features and operation of the plan presented by the Richvale Irrigation District, was analyzed by the Department as an alternative Middle Fork Project. Major changes in the plan included the elimination of Gold Lake and Grizzly Valley storage sites, and the elimination of gates on the spillway for Clio Dam. This latter change would reduce the storage capacity of the reservoir from the now (September 1960) proposed 156,400 acre-feet to 100,000 acre-feet. Other important changes in the plan were made in sizes of power plants, tunnels, and penstocks, to reflect the changes in the available water supply and in reservoir operation criteria.

The Modified Richvale Plan would include the construction of Clio and Nelson Point storage reservoirs, Minerva, Dogwood, Hartman Bar, and Bald Rock diversion reservoirs on the Middle Fork of the Feather River, and the five power plants of the Richvale Plan. The storage reservoirs would be operated to regulate the stream flow of the Middle Fork for releases downstream through the five power plants. In addition to the regulated water, the lower four power plants would receive significant amounts of water from uncontrolled runoff from local drainage areas. The plan is shown on Plate 9, entitled "Alternative Middle Fork Plans - Modified Richvale Plan and Turntable-Meadow Valley-Swayne Plan".

Monthly yield studies, based on the estimated available runoff, were conducted in sizing the project. A summary of the yield study for the size of project selected to illustrate its accomplishments is presented in Appendix B.

The Modified Richvale Plan would make new water available in the Feather River below Oroville on a firm irrigation demand schedule in the estimated amount of about 45,000 acre-feet seasonally.

It was estimated that the project would have an installed power capacity of 150,000 kilowatts, a dependable power capacity of 123,900 kilowatts, and would produce about 785,000,000 kilowatt-hours of energy seasonally.

New recreational opportunities would be made available by the project by providing a setting for the development of camp sites, boating facilities, and summer homes. Both the area surrounding the reservoirs and the Middle Fork canyon are attractive for this type of development.

Under the plan of development, Clio Reservoir, with a storage capacity of 100,000 acre-feet, would be created by construction of an earthfill dam 150 feet in height on the Middle Fork of the Feather River about one-half mile northwest of the community of Clio, in Sections 23 and 26, T22N, R12E, MDB&M. Water regulated in Clio Reservoir would be released for reregulation in Nelson Point Reservoir. Nelson Point Reservoir, with a storage capacity of 116,000 acre-feet, would be created by construction of a concrete arch dam 365 feet in height on the Middle Fork of the Feather River about three miles downstream from the junction of Nelson Creek with the Middle Fork, in Section 18, T23N, R10E, MDB&M. Water from Nelson Point Reservoir would be conveyed through a tunnel 0.35 mile in length and discharged through Power Plant No. 1. This plant would be located in Section 13, T23N, R9E, MDB&M, and would have an installed power capacity of 12,000 kilowatts. Minerva Dam would be a concrete arch structure, with a height of 81 feet and would be located in Sections 13 and 24, T23N, R9E, MDB&M. It would form a reregulating reservoir below Power Plant No. 1. From Minerva Dam, a tunnel 6.1 miles in length would extend to Power Plant No. 2 located at Sherman Bar in Section 36, T23N, R8E, MDB&M. This plant would have an installed power capacity of 28,000 kilowatts. Dogwood Dam would form a reregulating reservoir below Power Plant No. 2. The dam would be a concrete arch structure with a height of 165 feet and would be located just below the junction of Dogwood Creek and the Middle Fork of the Feather River, in Section 2, T22N, R8E, MDB&M. From Dogwood Dam, a tunnel 6.0 miles in length would convey the water to Power Plant No. 3, which would have an installed power capacity of 28,000 kilowatts. Power Plant No. 3 would be located at Hartman Bar, in Section 11, T22N, R7E, MDB&M. Hartman Bar Dam, with a height of 90 feet, would form a reregulating reservoir below Power Plant No. 3. This dam would be of concrete arch construction and would be located 0.4 mile downstream from the junction of Willow Creek and the

Middle Fork, in Section 11, T22N, R7E, MDB&M. From Hartman Bar Dam, a tunnel 7.7 miles in length would convey the water for discharge through Power Plant No. 4. This plant, with an installed power capacity of 40,000 kilowatts, would be located at Milsap Bar, in Section 2, T21N, R6E, MDB&M. Bald Rock Dam, a concrete arch structure 180 feet in height, located about one-half mile downstream from American Bar, in Sections 10, 11, and 14, T21N, R6E, MDB&M, would form a reregulating reservoir below Power Plant No. 4. From Bald Rock Dam, a tunnel 3.0 miles in length would convey water from the reservoir to Power Plant No. 5. This plant, with an installed power capacity of 42,000 kilowatts, would be located at the junction of Fall River and the Middle Fork of the Feather River, in Sections 34, 35, T21N, R6E, MDB&M. The project, as described, would have a total installed power capacity of 150,000 kilowatts.

The geologic investigations of the dam sites included in the Modified Richvale Plan consisted of a review of available reports and of field reconnaissances of the sites. The department did no foundation drilling of these sites during the Upper Feather River Basin Investigation.

A preliminary drilling program of Clio dam site was conducted by the Richvale Irrigation District in January 1953. The information obtained from this program was reviewed and utilized for the purposes of this investigation. Additional work conducted during the investigation included field reconnaissance and surface mapping of the Clio dam and reservoir site.

Clio Dam would be constructed on unconsolidated glacial outwash deposits which consist of boulders and cobbles in a matrix of sand, silt, and clay except for the right abutment which is composed of volcanic rock. No solid bedrock was encountered during the subsurface exploration along the axis of the dam. The left abutment is underlain by sandy clay and carbonaceous clay with some interbeds of coarse sand and lignite. A flow of artesian water was recorded from one of the holes for a period of 10 days. Springs and seeps may be noted along the southeastern slope of the left abutment ridge. The strength of the materials underlying the left abutment has not been adequately determined. However, it is believed that the material probably would support a dam of the height being considered. Cutoff beneath the left abutment of a dam could be obtained by completely blanketing the abutment with impervious material.

The channel section is filled to a depth of about 20 feet with cobbles, gravel, sand, and silt. These alluvial deposits would have to be removed beneath the impervious section of the dam. In addition, a deep cut-off would be required to stop underflow through the numerous coarse sand lenses.

The right abutment is composed of volcanic rock. The rock is prominently jointed and deeply weathered. About 10 feet of overburden and numerous large blocky outcrops would have to be removed from beneath the impervious section of the dam. The very long spillway from the left abutment of the dam to the Middle Fork of the Feather River should be designed to prevent excessive erosion of the glacial outwash material.

Adequate supplies of suitable impervious borrow material may be obtained from the reservoir area within a short distance of the site. Pervious gravels may be obtained from the channel of the Middle Fork of the Feather River.

A major fault cuts through the dam site near the base of the right abutment. The contact between the fine-grained lake bed and glacial materials against the nearly vertical face of the igneous rocks probably represents a weakness in the foundation. Evidence of recent faulting, such as sulphur springs and fissures occur in the Mohawk Valley area. This faulting indicates the possibility of high seismicity at this dam site. In addition, leakage would occur through the sediments underlying the dam site unless extensive treatment is effected. The stability of these sediments under load is questionable. Geologic conditions of the Clio dam site are shown on Plate 12, entitled "Clio Dam on Middle Fork Feather River".

Geologic investigation of the Nelson Point dam site was limited to a field reconnaissance of the site. The dam site is located in a rugged, steep-walled gorge of the Middle Fork of the Feather River. Bedrock in the area consists of interbedded quartzite, chlorite schist, and various other schists and meta-sandstones. Some quartz veins cut the rocks. All of the rocks belong to the Calaveras formation. The strike of the beds is perpendicular to the general course of the river in the area of the dam site. Outcrops flanking the river at the dam site extend as uneven vertical bluffs up to a height of approximately 100 feet above stream bed. Depth of stripping of the abutments for an arch dam would depend on the depth of weathering and strength of materials of the abutments. Based on the brief geologic reconnaissance, Nelson Point dam site appears suitable for the construction of a concrete arch dam of the height being considered.

Geologic investigation of the Minerva dam site consisted of a limited field reconnaissance of the site. As proposed by the Richvale Irrigation District, the Minerva site would be located approximately one mile downstream from the Nelson Point dam site. However, a concrete dam at this location does not seem advisable because the foundation material is serpentine. It is believed that the Minerva dam site should be moved about 2,000 feet upstream to a location where more favorable foundation conditions exist in the bedrock of the Calaveras formation. Foundation conditions at this upper axis should be generally similar to those described for Nelson Point dam site.

Geologic investigation of the Dogwood dam site consisted of a limited field reconnaissance of the site. The foundation rock is a massive quartzite belonging to the Calaveras formation. Also present at the site are numerous granitic dikes and minor amounts of schist and phyllite. Bedrock is exposed on both abutments to a height of about 80 feet above the river. Depth of stripping of the abutments would depend on the extent of weathering of the abutment rock. Unless additional foundation exploration indicates otherwise, 10 feet would appear to be a reasonable stripping depth. At the axis of the dam site, the channel section is about 80 feet wide and extremely irregular. Average depth of fill of sand, gravel, and large boulders in the channel is estimated at about 10 feet. Based on the brief geologic reconnaissance, Dogwood dam site appears suitable for the construction of an arch dam of the height being considered.

Geologic investigation of the Hartman Bar dam site consisted of a limited field reconnaissance of the site. The site is located in a steep-walled gorge of the Middle Fork of the Feather River. Foundation rock consists of moderately jointed, fresh, very coarse-grained biotite granodiorite. On the right abutment, the granodiorite crops out at a height of about 150 feet above the river. Outcrops of granodiorite are continuous on the left abutment to a height of about 20 feet above the channel. Higher on the abutment the bedrock is covered by old channel deposits which form a moderately sloping terrace. At the axis of the dam site, the channel section is about 100 feet wide. Channel fill consists of sand, gravel, and boulders to an average depth of about 10 feet.

Suitability of this site could not be determined from the brief field reconnaissance. Of particular concern were terrace deposits located on the left abutment. Suitable foundation conditions, however, appear to exist at an alternative axis located about 1,000 feet downstream from the site considered.

The geologic investigation of the Bald Rock dam site consisted of a limited field reconnaissance of the site. The site is located in a steep-walled gorge of the Middle Fork of the Feather River. Granitic bedrock outcrops almost continuously on both abutments. The foundation rock at the dam site appears to be well suited to the construction of an arch dam. Stripping would include the removal of about 15 feet of weathered rock from each abutment and the excavation of an average of about 10 feet of boulders, cobbles, and sand from the channel section. In addition, an estimated average of five feet of bedrock should be excavated from the channel to prepare for the base of the dam. Based on a brief geologic reconnaissance, it appears that the Bald Rock site is suitable for the construction of an arch dam of the height being considered.

The geologic investigation of the tunnel routes included in the Modified Richvale Plan consisted of a review of published data and a brief field reconnaissance of the routes. The geologic conditions of the tunnel routes are shown on Plate 11.

A short, high pressure tunnel would extend from Nelson Point Reservoir to Power Plant No. 1. The tunnel would penetrate rocks of the Calaveras formation which may include beds of phyllite, schist, quartzite, and limestone. For purposes of tunnel design, the rock was classified as very blocky and seamy. As the tunnel would be a pressure tunnel, reinforcing and lining would be required throughout its length. Overbreak should not be excessive since the tunnel would be driven approximately normal to the strike of the bedding.

The tunnel from Minerva Dam to Power Plant No. 2 would be approximately six miles in length of which about the first three miles would be in serpentine rock. A large-diameter tunnel could be constructed through this serpentine, but the attendant risks and construction expense in such rock are usually great. Water-bearing shear zones and fault zones can be expected in the serpentine. Squeezing, popping, and running ground may be encountered. The tunnel in serpentine would have to be strongly supported and heavily lined throughout its length.

The last three miles of tunnel between Minerva Dam and Power Plant No. 2 would penetrate rocks of the Calaveras formation. The rocks penetrated would include phyllite, schist, and quartzite and should be classified as blocky and seamy. Overbreak should not be extensive because the bore would be oriented almost perpendicular to the structure of the rock. However, support and lining should be planned for at least 50 percent of the length of this section of the tunnel.

The tunnel from Dogwood Reservoir to Power Plant No. 3 located at Hartman Bar would be about nine feet in diameter and six miles in length. The tunnel would penetrate the interbedded phyllite, schist, quartzite, and limestone of the Calaveras formation and would encounter one short zone of granodiorite. The tunnel would penetrate a major fault within about one-half mile of the intake portal. West of this point, tunneling conditions should be as good as can be expected in the Calaveras formation. The tunnel would be oriented almost normal to the beds and structures of the rock, and overbreak would not be unduly high. The tunnel would require moderate support. Almost continual lining also may be required to prevent leakage of water under pressure through the joints of the bedrock. The short section of granodiorite which would be encountered probably would be faulted and sheared. In this rock, overbreak may be somewhat higher. The rock should be classified as very blocky and seamy.

The tunnel between Hartman Bar and Power Plant No. 4, located at Milsap Bar, would be about 7.7 miles in length and 14.5 feet in diameter.

The intake portal of the tunnel would be located in granitic rock. Heavy support and lining probably would be required for the first 50 to 150 feet of the tunnel. For the next two miles of the tunnel, support and lining in the granitic rock probably would be light. A zone of Calaveras formation having a width of about one mile would be encountered three miles from the intake portal. Near this zone it is expected that the granitic rock would become progressively more sheared and that overbreak would increase. In this area the need for support and lining would increase. Tunneling conditions in the Calaveras rocks would be about as described for the tunnel between Dogwood Dam and Hartman Bar, since both tunnels would penetrate similar rocks normal to the structure. Support and lining probably would be needed continuously. The rock near the contact between the granodiorite and the Calaveras formation may be strongly sheared and crushed and probably would require very strong support and heavy lining. It is estimated that about 50 percent support and lining would be required for two miles of the tunnel in the granodiorite area west of the Calaveras formation. The final mile of tunnel probably would require heavy support and lining in view of the proximity of this area to the contact with the Calaveras formation and to the outlet portal.

The tunnel extending from Bald Rock dam site to Power Plant No. 5 would have a length of about three miles and an unlined diamter of 14.51 feet. The rock encountered would be predominantly granodiorite and would be some of the most competent rock to be encountered in this part of the Sierra Nevada. The tunnel portals should be in reasonably sound rock. A minimum of tunnel support and lining could be expected.

As previously stated in Chapter II, the engineering designs of the features of the Modified Richvale Plan were of a preliminary nature. Additional field exploration and study may develop information that substantially could change the designs and estimates of cost presented herein. With the exception of Clio Dam, the designs of dams presented herein were developed by the Richvale Irrigation District. The principal features of Clio Dam are delineated on Plate 12.

Pertinent data with respect to general features of the Modified Richvale Plan as designed for preliminary cost estimating purposes, are summarized in Table 33.

The economic analysis of the Modified Richvale Plan consisted of a preliminary determination of the economic justification of the project. This work entailed a comparison of the estimated project benefits and costs to determine the overall project benefit-cost ratio.

The capital cost of the Modified Richvale Plan was estimated to be about $117,853,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, were estimated to be about $8,210,000. Of this amount, the estimated value of taxes foregone would be $1,269,000. An estimate of the cost of individual project features is presented in Appendix C. A summary of capital and annual costs of the project is presented in Table 34.

The benefits that would accrue to the Modified Richvale Plan would result from production of hydroelectric power, from new water supplies, and from increased recreational opportunities in the area. Some minor flood control benefits would accrue from operation of the proposed reservoirs even though specific flood control features were not included. However, incidental benefits were not evaluated and economic justification was based solely on hydroelectric power, irrigation, and recreational benefits. Hydroelectric power benefits estimated at $5,025,000 annually, on the average, would be realized from the operation of the five power plants of the Modified Richvale Plan.

TABLE 33

GENERAL FEATURES OF THE MODIFIED RICHVALE PLAN

Dam and reservoir	Stream	Dam: Location MDB&M	Dam: Type 1/	Dam: Height, in feet	Dam: Crest, length, in feet	Water surface elevation, in feet: Normal pool	Water surface elevation, in feet: Minimum pool	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active
Clio	M.F. Feather River	S. 23 T22N R12E	E	150	2,630	4,487	4,427	100,000	84,000
Nelson Point	M.F. Feather River	S. 18 T23N R10E	CA	365	900	4,030	3,850	116,000	104,000
Minerva	M.F. Feather River	S. 13, 24 T23N R9E	CA	81	303	3,670	---	---	---
Dogwood	M.F. Feather River	S. 2 T22N R8E	CA	165	480	2,960	---	---	---
Harman Bar	M.F. Feather River	S. 11 T22N R7E	CA	90	355	2,320	---	---	---
Bald Rock	M.F. Feather River	S. 10, 11 T21N R6E	CA	180	405	1,580	---	---	---

Power Plant	Location MDB&M	Maximum gross static head, in feet	Minimum gross static head, in feet	Average head loss, in feet	Installed capacity, in kilowatts	Dependable capacity in kw	Average seasonal energy in: mwh 2/	Peak flow, in second-feet	Headwater elevation, in feet	Tailwater elevation, in ft.
No. 1	S. 13 T23N R9E	360	180	7	12,000	---	---	520	4,030	3,670
No. 2	S. 36 T23N R8E	710	710	80	28,000	---	---	617	3,670	2,960
No. 3	S. 11 T22N R7E	640	640	75	28,000	---	---	690	2,960	2,320
No. 4	S. 2 T21N R6E	740	740	90	40,000	---	---	855	2,320	1,580
No. 5	S.34,35 T21N R6E	680	680	40	42,000	---	---	910	1,580	900
Total system					150,000	123,900	785,000	---	---	---

Tunnel	Capacity, in second-feet	Diameter, in feet: lined	Diameter, in feet: Unlined	Cross section	Percentage lined	Length, in feet
Nelson Point-P.P. No. 1	520	8.0	---	Circular	100	1,900
Minerva-P.H. No. 2	617	8.75	---	Horseshoe	100	32,200
Dogwood Bar-P.H. No. 3	690	9.25	---	Horseshoe	100	31,600
Hartman Bar-P.H. No. 4	855	11.5	13.5	Horseshoe	48	40,600
Bald Rock-P.H. No. 5	910	12.5	14.5	H	20	15,900

1/ Type:
E = Earthfill
CA= Concrete arch

2/ mwh-Megawatt-hours

TABLE 34

SUMMARY OF ESTIMATED COSTS OF MODIFIED RICHVALE PLAN

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$86,185,000
Lands, easements, and rights of way	1,142,000
Relocation of public utilities	1,714,000
Subtotal	$89,041,000
Engineering and administration	$ 9,093,000
Contingencies	12,783,000
Interest during construction	6,940,000
TOTAL CAPITAL COST	$117,853,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 5,498,000
Operation and maintenance, replacement, general expense, and insurance	1,306,000
Taxes foregone	1,269,000
Subtotal	$ 8,073,000
Recreational features	
Public facilities,iincluding operation and maintenance	$ 137,000
TOTAL ANNUAL COST	$ 8,210,000

Irrigation benefits would be realized from the estimated 45,000 acre-feet of new water that would be made available on an irrigation demand schedule from the operation of the Modified Richvale Project. The estimated irrigation benefits would be about $360,000 seasonally.

Recreational benefits would accrue to the Modified Richvale Plan from an enhancement of the Clio and Nelson Point reservoir areas and from the Middle Fork Canyon area below Nelson Point Reservoir. Only those recreational benefits estimated to be derived from public recreational facilities were evaluated. The estimated net annual recreational benefits would be $66,000 for Clio Reservoir, $110,000 for Nelson Point Reservoir, and $106,000 for other reservoirs on the Middle Fork of the Feather River. The derivation of these benefits is discussed in detail in Appendix A.

Total estimated benefits from all sources for the Modified Richvale Plan are summarized in Table 35.

TABLE 35

ESTIMATED AVERAGE ANNUAL NET BENEFITS FOR THE MODIFIED RICHVALE PLAN

Purpose	Benefits
Hydroelectric Power	$5,025,000
Irrigation	360,000
Recreation	282,000
TOTAL	$5,667,000

The resulting ratio of benefits to costs for the Modified Richvale Plan would be 0.69 to 1 (1959).

Clio-Nelson Point-Swayne Plan

The Clio-Nelson Point-Swayne Plan is a further modification of the previously described Richvale Plan. It was studied as an alternative possibility for developing the waters of the Middle Fork of the Feather River Basin. The additional modification would consist of diverting the regulated waters from Hartman Bar Reservoir for storage in the proposed Swayne Reservoir on French Creek. From Swayne Reservoir, the regulated water would be conveyed to and dropped through a power plant located on lower French Creek, shore of Oroville Reservoir. The storage reservoirs and power plants would be operated conjunctively to utilize available flows to maximize the dependable power capacity of the total system.

Monthly yield studies, based on the estimated available runoff, were conducted in sizing the project. A summary of the yield study for the size of project selected is presented in Appendix B.

The Clio-Nelson Point-Swayne Plan would produce new water on a firm irrigation demand schedule in the estimated amount of 137,000 acre-feet seasonally. This estimate was based on conditions expected to prevail in the future, when water supplies available to the project would have been reduced to meet requirements for upstream use.

It was estimated that the project would have an installed power capacity of 195,500 kilowatts and a dependable power capacity of 174,800 kilowatts. The project would produce about 909,000,000 kilowatt-hours of energy seasonally.

New recreational opportunities would be made available by the project. It would enhance outdoor recreation in the area by providing a setting for the development of camp sites, boating facilities, and summer homes. The areas surrounding the proposed reservoirs and the Middle Fork Canyon are attractive for this type of development. Location of the project is shown on Plate 10, entitled "Alternative Middle Fork Plans, Clio-Nelson Point-Swayne Plan, and Nelson Point-Meadow Valley-Bald Rock Plan".

Under the plan of development, Clio Reservoir, with a storage capacity of 100,000 acre-feet, would be created by construction of an earthfill dam 150 feet in height on the Middle Fork of the Feather River about one-half mile below Clio in Sections 23 and 26, T22N, R12E, MDB&M. The regulated water from Clio Reservoir would be released for reregulation in Nelson Point Reservoir. Nelson Point Reservoir, with a storage capacity of 116,000 acre-feet, would be created by construction of a concrete arch dam 365 feet in height on the Middle Fork of the Feather River, about three miles downstream from the junction of Nelson Creek with the Middle Fork in Section 18, T23N, R10E, MDB&M. The regulated flow from Nelson Point Reservoir would be released through a tunnel 0.35 mile in length and discharged through Power Plant No. 1. This plant would be located in Section 13, T23N, R9E, MDB&M, and would have an installed power capacity of 12,000 kilowatts. Minerva Dam would be constructed to form a reregulating reservoir below Power Plant No. 1. It would be a concrete arch structure 81 feet in height, and located in Sections 13 and 24, T23N, R9E, MDB&M. From Minerva Dam, a tunnel 6.1 miles in length would extend to Power Plant No. 2. This plant would be located at Sherman Bar, in Section 36, T23N, R8E, MDB&M, and would have an installed power capacity of 28,000 kilowatts. Dogwood Dam would be constructed to form a reregulating reservoir below Power Plant No. 2. It would be a concrete arch structure with a height of 165 feet and would be located just below the junction of Dogwood Creek and the Middle Fork of the Feather River, in Section 2, T22N, R8E, MDB&M. From Dogwood Dam, a tunnel six miles in length would convey the water to Power Plant No. 3, which would have an installed power capacity of

28,000 kilowatts, and would be located at Hartman Bar, in Section 11, T22N, R7E, MDB&M. Hartman Bar Dam, with a height of 175 feet, would be constructed to form a reregulating reservoir below Power Plant No. 3. This dam would be of concrete arch construction and would be located 0.4 mile downstream from the junction of Willow Creek and the Middle Fork of the Feather River in Section 11, T22N, R7E, MDB&M. From Hartman Bar Dam, a tunnel 6.4 miles in length would convey the regulated waters to Spoon Diversion Works located on Little North Fork in Section 27, T22N, R6E, MDB&M. Spoon Diversion Dam would be of concrete gravity construction and would have a height of 25 feet. From Spoon Diversion, a tunnel 1.8 miles in length would convey the regulated water for storage in Swayne Reservoir on French Creek. Swayne Dam would be of zoned earthfill construction, with a height of 380 feet and would be located about three miles upstream from the confluence of French Creek with the North Fork in Section 35, T22N, R5E, MDB&M. From Swayne Reservoir, a tunnel 1.3 miles in length would convey the regulated water to Swayne Power Plant. This plant, with an installed capacity of 127,500 kilowatts, would be located on French Creek about one mile upstream from its confluence with the North Fork in Section 10, T22N, R5E, MDB&M. The project, as described, would have a total installed capacity of 195,500 kilowatts.

Since geologic conditions at the Clio, Nelson Point, Minerva, Dogwood, and Hartman Bar dam sites were described previously under the discussion of the Modified Richvale Project, only the Swayne dam site is discussed in this section.

The geologic investigation of Swayne dam site consisted of both regional and detailed geologic site mapping. The program included: (1) geologic mapping of the dam, reservoir, and powerhouse sites, and of the power tunnel route; (2) core drilling and sampling of 11 holes having an aggregate length of 1,160 feet along the axis of the dam site and in two possible saddle spillway sites; (3) obtaining undisturbed samples of foundation materials; (4) conducting seismic studies to determine the depth of decomposed granodiorite in the left abutment and beneath a spillway saddle; (5) mapping and sampling of possible construction material borrow areas; and (6) resistivity studies to determine the depth and volume of dredge tailings in the reservoir area.

Swayne dam site is located in a deep canyon of French Creek. Bedrock at the dam site and in the area of the tunnel route is granodiorite which may be broken down into two sub-units: (1) fresh, competent, hard granodiorite; and (2) soft, crumbly, decomposed granodiorite. The fresh granodiorite is generally confined to stream channel areas. Elsewhere, the depth of decomposed granodiorite is highly irregular and very difficult to determine. Close to the surface, where the weathering is most intense, the clay content of the decomposed rock is high. Below the clayey zone, the clay content decreases and the rock becomes more crumbly. At the dam site, the decomposed granodiorite becomes progressively deeper, higher on the abutments and extends to a depth of 100 feet or more in the upper portions of both abutments. The outcrops of apparently fresh granodiorite in the decomposed rock are residual boulders of weathering. The irregular slope and depth of decom;osed granodiorite on the left abutment at the site may be indicative of a fault system which parallels the general course of the stream.

Stripping beneath both the impervious and pervious sections of the dam should average about 10 feet on the abutments. Shaping of the bedrock would be necessary only in the channel section. Sufficient quantities of materials for construction of a dam are available within 1.5 miles of the dam site. Extensive deposits of dredge tailings are available in the reservoir site.

No recent fault scarps were observed in the area, but a few minor faults and shear zones are known to exist. The seismicity of the area is considered to be low to moderate.

Swayne dam site appears geologically suitable for the construction of a zoned earthfill dam. Geologic conditions at the Swayne dam site are shown on Plate 13.

No detailed geologic study was made of the Spoon diversion site. Geologic conditions of the area are shown on Plate 11.

The geologic investigations of the tunnel routes included in the Clio-Nelson Point-Swayne Plan consisted of a review of published data and a brief field reconnaissance of the routes. The geologic conditions of the tunnel routes in the Middle Fork Canyon are shown on Plate 11 and were previously discussed under the Modified Richvale Plan. The inlet portal, and the first 2.3 miles of the Hartman Bar-Little North Fork Tunnel, should be in reasonably good granitic rock. Following the granitic rock, the tunnel should penetrate about one mile of Calaveras formation, after which about 1.5 miles of granodiorite again should be encountered. The granitic rocks probably would be sheared and crushed near the contacts and could be expected to require heavy support and lining. Moderate support and almost continuous lining would be required in the Calaveras rocks.

The Little North Fork-Swayne Tunnel probably would not need support or lining, inasmuch as the tunnel would penetrate a broad zone of granodiorite at some distance from any known contact or faults.

The tunnel connecting Swayne Reservoir and the power plant located at the mouth of French Creek would penetrate about one mile of granodiorite and decomposed granite and about one-quarter mile of schist. The inlet portal would be founded on fresh granodiorite exposed on the nose of an ascending ridge at an elevation of about 2,000 feet. Light to moderate support probably would be required in the fresh granodiorite. Zones of decomposed granite may require heavy support. Light to moderate support should be anticipated through the schist.

As previously described in Chapter II, the engineering designs of the Clio-Nelson Point-Swayne Plan were of a preliminary nature. Additional field exploration could change substantially the designs and estimates of costs presented herein. The preliminary designs as developed by the Richvale Irrigation District for all dams on the Middle Fork of the Feather River below Clio Dam were utilized for the purposes of this investigation.

Pertinent data with respect to general features of the Clio-Nelson Point-Swayne Plan as designed for preliminary cost estimating purposes, are presented in Table 36.

The economic analysis of the Clio-Nelson Point-Swayne Plan consisted of a preliminary determination of the economic justification of the project. This work entailed a comparison of the estimated project benefits and costs to determine the overall project benefit-cost ratio.

The capital costs of the Clio-Nelson Point-Swayne Project was estimated to be about \$156,074,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, were estimated to be about \$10,618,000. Of this amount, the estimated annual value of taxes foregone would be about \$1,654,000. An estimate of costs of individual project features is presented in Appendix C. A summary of capital and annual costs and the value of taxes foregone is presented in Table 37.

TABLE 36

GENERAL FEATURES OF THE CLIO-NELSON POINT-SWAYNE PLAN

Dam and reservoir	Stream	Dam: Location MDB&M			Dam: Type 1/	Dam: Height, in feet	Dam: Crest, length, in ft.	Water surface elevation, in feet: Normal pool	Water surface elevation, in feet: Minimum pool	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active
Clio	M.F. Feather River	S. 23,/26	T22N	R12E	E	150	2,630	4,487	4,427	100,000	84,000
Nelson Point	M.F. Feather River	S. 18	T23N	R10E	CA	365	900	4,030	3,850	116,000	104,000
Minerva	M.F. Feather River	S. 13 24	T23N	R9E	CA	81	303	3,670	---	---	---
Dogwood	M.F. Feather River	S. 2	T22N	R8E	CA	165	480	2,960	---	---	---
Hartman Bar	M.F. Feather River	S. 11	T22N	R7E	CA	175	600	2,405	---	---	---
Spoon Div.	Little North Fork	S. 27	T22N	R6E	CG	25	150	2,345	---	---	---
Swayne	French Creek	S. 35	T22N	R5E	E	380	2,700	2,330	2,095	280,000	262,000

Power plant	Location MDB&M			Maximum gross static head, in feet	Minimum gross static head, in feet	Average head loss, in feet	Installed capacity, in kilowatts	Dependable capacity, in kw.	Average annual energy, in mwh 2/	Peak flow, in second-feet	Head water elev., in ft.	Tail-water elev., in ft.
No. 1	S. 13	T23N	R9E	360	180	7	12,000)			520	4,030	3,670
No. 2	S. 36	T23N	R8E	710	710	80	28,000)	47,300	317,000	617	3,670	2,960
No. 3	S. 11	T22N	R7E	537	537	72	28,000)			805	2,960	2,423
Swayne	S. 10	T21N	R5E	1,430	1,195	30	127,500	127,500	592,000	1,520	2,330	900
Total system						252	195,500	174,800	909,000			

Tunnel	Capacity, in second-feet	Diameter, in feet: Lined	Diameter, in feet: Unlined	Cross section	Percentage lined	Length in feet
Nelson Point-PH No. 1	520	8.00		Circular	100	1,900
Minerva-PH No. 2	617	8.75		Horseshoe	100	32,200
Dogwood-PH No. 3	805	9.5		Horseshoe	100	24,000
Hartman Bar-Spoon	900	12.25	14.25	Horseshoe	67	34,900
Spoon-Swayne	1,100 3/	13.75	16.00	Horseshoe	47	9,400
Swayne-Swayne PH	1,520	14.33		Circular	100	6,800

1/ Type: E = Earthfill
CA = Concrete arch
CG = Concrete gravity
2/ mwh = megawatt hours
3/ 5,200 second-feet for stream diversion during dam construction.

TABLE 37

SUMMARY OF ESTIMATED COSTS OF
CLIO-NELSON POINT-SWAYNE PLAN

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$114,328,000
Lands, easements, and rights of way	1,358,000
Relocation of public utilities	1,714,000
Subtotal	$117,400,000
Engineering and administration	11,930,000
Contingencies	17,039,000
Interest during construction	9,705,000
TOTAL CAPITAL COST	$156,074,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 7,265,000
Operation, maintenance, replacement, general expense, and insurance	1,537,000
Taxes foregone	1,654,000
Subtotal	$ 10,456,000
Recreational features	
Public facilities, including operation and maintenance	$ 162,000
TOTAL ANNUAL COST	$ 10,618,000

The benefits that would accrue to the Clio-Nelson Point-Swayne Plan would result from production of hydroelectric energy, from new water supplies, and from increased recreational opportunities in the area. Some incidental flood control benefits would accrue from operation of the proposed reservoirs even though specific flood control features were not included. However, incidental benefits were not evaluated and economic justification of the project was based solely on hydroelectric power, irrigation, and recreational benefits. Average annual hydroelectric power benefits estimated at $6,512,000 would be realized from the operation of the four power plants of the Clio-Nelson Point-Swayne Plan.

Irrigation benefits would be realized from the estimated 137,000 acre-feet of new water that would be made available on an irrigation demand schedule from the operation of the Clio-Nelson Point-Swayne Project. The estimated irrigation benefits would be about $1,096,000 seasonally.

Recreational benefits would accrue to the project from an enhancement of the Clio, Nelson Point, and Swayne reservoir areas and from the Middle Fork Canyon area below Nelson Point Reservoir. Only those recreational benefits estimated to be derived from public recreational facilities were evaluated for this study. The estimated net annual recreational benefits would be $66,000 for Clio Reservoir, $110,000 for Nelson Point Reservoir, $59,000 for Swayne Reservoir, and $120,000 for the Middle Fork Canyon area. The derivation of these benefits is discussed in detail in Appendix A.

Total benefits from all sources are summarized in Table 38.

TABLE 38

ESTIMATED AVERAGE ANNUAL NET BENEFITS
FROM CLIO-NELSON POINT-SWAYNE PROJECT

Purpose	Benefit
Hydroelectric power	$ 6,512,000
Irrigation	1,096,000
Recreation	355,000
TOTAL	$ 7,963,000

The resulting ratio of benefits to costs for the Clio-Nelson Point-Swayne Plan would be 0.75 to 1 (1959).

Nelson Point-Meadow Valley-North Fork Plan

This plan would include the construction of Nelson Point Dam and Reservoir on the Middle Fork of the Feather River, the diversion of the waters of Nelson Point Reservoir by tunnel to the proposed Meadow Valley Reservoir on Spanish Creek, and the conveyance of the conserved water from Meadow Valley Reservoir by tunnel to a power plant located on the North Fork of the Feather River about one mile upstream from Belden. Flood flows of Bear Creek, a tributary of the Middle Fork, would be diverted by the Red Ridge diversion works to Meadow Valley Reservoir to augment the yield from the latter reservoir.

Monthly yield studies based on the estimated available runoff, were conducted in sizing the project. A summary of the yield study for the size of project selected is presented in Appendix B.

The Nelson Point-Meadow Valley-North Fork Plan would produce new water on a firm irrigation demand schedule in the estimated amount of about 133,000 acre-feet seasonally. This estimate was based on conditions expected to prevail in the future, when water available to the project would have been reduced to meet requirements for upstream use.

It was estimated that Meadow Valley Power Plant would have an installed power capacity of 118,500 kilowatts, a dependable power capacity of 118,500 kilowatts, and would produce about 506,000,000 kilowatt-hours of energy seasonally. In addition, it is estimated 346,000,000 kilowatt-hours of energy would be realized in the existing North Fork power plants of the Pacific Gas and Electric Company.

New recreational opportunities would be made available by the project by providing a setting for the development of camp sites, boating facilities, and summer homes. Both the area surrounding the reservoirs and the Middle Fork Canyon area are attractive for this type of development.

Location of the project is shown on Plate 8, entitled "Alternative Middle Fork plans, Richvale Plan and Nelson Point-Meadow Valley-North Fork Plan".

Under the plan of development, Nelson Point Reservoir, with a storage capacity of 116,000 acre-feet, would be created by construction of a concrete arch dam 365 feet in height about three miles downstream from the junction of Nelson Creek with the Middle Fork in Section 18, T23N, R10E, MDB&M. The regulated flow from Nelson Point Reservoir would be released through a tunnel 7.8 miles in length for storage in Meadow Valley Reservoir on Spanish Creek. This reservoir, with a storage capacity of 900,000 acre-feet, would be created by construction of a zoned earthfill dam 464 feet in height, about three miles west of Quincy, in Section 17, T24N, R9E, MDB&M.

Red Ridge diversion works would be created by construction of a concrete gravity dam 25 feet in height on Bear Creek in Section 16, T23N, R8E, MDB&M. The water intercepted by the diversion structure would be conveyed through a tunnel 3.6 miles in length to be discharged into Meadow Valley Reservoir. The regulated waters from Meadow Valley Reservoir would be released through a lined tunnel 9.7 miles in length to be discharged through the Meadow Valley Power Plant. This plant would be located in Section 19, T25N, R7E, MDB&M and would have an installed power capacity of 118,500 kilowatts.

The geologic investigation of the dam sites for the Nelson Point-Meadow Valley-North Fork Plan consisted of a field reconnaissance of the Nelson Point and Red Ridge dam sites and foundation drilling and geologic mapping of the Meadow Valley dam site.

A description of the geologic conditions at the Nelson Point dam site was presented herein under the discussion of the Richvale Plan. The geologic investigation of the Meadow Valley dam site included: (1) subsurface exploration by means of 11 diamond drill core holes totaling 1,524 lineal feet, and (2) geologic mapping of the site.

Meadow Valley dam site is in a narrow, fairly steep-walled gorge cut by Spanish Creek. The stream follows a tortuous channel around alternating meander spurs near the dam site. Based on preliminary drilling results, the Meadow Valley dam site appears suitable for a zoned earthfill dam with a height of up to 500 feet.

The three geologic units that occur at the site are recent stream gravels in the channel, miocene gravely sandy clay at the top of the left abutment, and the Calaveras formation which comprises the bedrock at the site. The rock types found at the dam site are quartzites, phyllites, and schists with variations and gradations from one type to another. Diamond drill cores indicate that the metamorphic rocks are generally competent enough to support an earthfill or concrete gravity dam. The beds dip almost vertically and strike N30°W. Slaty cleavage is not as well developed in this area as it generally is in phyllitic and schistose rocks.

No recent large faults or shear zones were encountered at the dam site; however, many small shear zones are present. These shear zones are all apparently parallel to the bedding and do not appear to affect the rock as a foundation for a fill dam. The shears, joints, and cleavage partings may make heavy grouting necessary.

On the right abutment, an estimated average of 10 feet of soil and weathered loose rock would have to be stripped under the impervious core of a dam. Under the pervious section of a dam, at least five feet of overburden should be stripped. The channel section would require an average of about 30 feet of stripping of sand and gravel. The bedrock immediately under the channel fill is reasonably hard and fresh, and would require only shaping of irregularities. Bedrock is exposed over much of the lower 200 feet of the left abutment. From this area, an average of about six feet of soils and weathered rock should be removed under the impervious core section and three feet under the pervious section of a dam. From about 200 feet above the channel to the top of the abutment, bedrock is deeply weathered. Stripping of 15 feet under the impervious section of the dam and six feet under the pervious section probably would be necessary. High on both abutments, the bedrock has slumped and may require stripping up to 40 feet of unstable rock. Further exploration may show this slumped rock to be competent enough for the foundation of an earthfill dam.

Topographically, the most desirable location for a spillway is above the left abutment. This area is one of very deep weathering and of slumped bedrock. A spillway in this area would require a cut with a depth of about 100 feet. The decomposed rock excavated in such a cut may be suitable for impervious fill.

Downstream From Meadow Valley Dam Site

Sufficient impervious and pervious fill material for an earthfill dam is located within three miles of the dam site. Impervious materials occur near the ridge tops surrounding Meadow Valley as Miocene stream channel deposits. The material is an auriferous gravel and is classified as a gravely sandy clay. These deposits have been extensively placer mined. Some of the material has been reworked. As a result, it has a high sand and gravel content, but is still classified as impervious.

A deposit of pervious fill is located about 1.5 miles downstream from the dam site at the head of American Valley. It is composed of Recent sands and gravels deposited by Spanish Creek. Other sources of pervious material exist upstream from the dam site. The upstream deposits are irregular in width and depth, and are located in a high-water table area. Haul distances would vary from two to five miles.

The seismicity of the area should be considered as at least moderate. The Spanish Peak fault is located about five miles west of the dam site. Although no movement along this fault has been recorded during historic time, it may still be active. Geologic conditions of the Meadow Valley dam site are shown on Plate 16, "Meadow Valley Dam on Spanish Creek".

The geologic investigation of the tunnel routes of the Nelson Point-Meadow Valley-North Fork Plan consisted of a review of published data and a brief field reconnaissance of the routes. The geologic conditions of the tunnel routes are shown on Plate 11.

The tunnel route from Nelson Point Reservoir to Meadow Valley Reservoir is almost entirely within Calaveras formation. Much of the ground would be very blocky and seamy with high overbreak. Fairly firm rock for an outlet portal is available along Spanish Creek about one-half mile east of Slate Creek.

The intake portal for the tunnel from Meadow Valley Reservoir to the power plant would be located in serpentine rock. With proper alignment of the tunnel, however, only about one-half mile of the serpentine need be penetrated before the tunnel would enter the Calaveras formation. In the tunnel in the serpentine formation, lining and support necessarily would be very heavy.

The tunnel would be located in the Calaveras formation for the remainder of the route. Tunneling through the Calaveras formation would involve moderately high to high overbreak and almost continuous support and lining. Light to moderate flows of water from joints and shear zones should be anticipated.

The tunnel portal for the Red Ridge-Meadow Valley Tunnel would be in sound granitic rock. The tunnel would continue in this rock for about one mile after which a major fault zone would be encountered near the contact between the granitic rock and the Calaveras formation. Heavy support and lining would be required through this zone. Water flowing into the tunnel under considerable pressure should be anticipated. For the next two miles, the tunnel would penetrate the Calaveras formation and would encounter blocky and seamy conditions and moderately high overbreak. Because of the proximity to major faults in the area, it is anticipated that the tunnel would require heavy support and continuous lining. The tunnel would penetrate about one-half mile of serpentine between the Calaveras formation and the outlet portal in Meadow Valley. Heavy support and continuous lining would be required in the serpentine.

The engineering designs of the Nelson Point-Meadow Valley-North Fork Project were of a preliminary nature. Additional field exploration and study may develop information that substantially could change the designs and estimates of costs presented herein. The design of the Nelson Point Dam as developed by the Richvale Irrigation District was utilized for the purpose of this investigation. Pertinent data with respect to general features of the Nelson Point-Meadow Valley-North Fork Plan, as designed for preliminary cost estimating purposes, are presented in Table 39.

The economic analysis of the Nelson Point-Meadow Valley-North Fork Plan for developing the waters of the Middle Fork of the Feather River consisted of a preliminary determination of the economic justification of the project. This work entailed a comparison of the estimated project benefits and costs to determine the overall project benefit-cost ratio. The capital cost of the Nelson Point-Meadow Valley-North Fork Plan was estimated at $143,374,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years were estimated to be about $8,926,000. Of this amount, the estimate of the annual value of taxes foregone is $1,003,000. An estimate of the costs of individual project features is presented in Appendix C. A summary of capital and annual costs and of the costs of taxes foregone for the Nelson Point-Meadow Valley-North Fork Plan is presented in Table 40.

Benefits would accrue to the Nelson Point-Meadow Valley-North Fork Plan from the production of hydroelectric power, from new water supplies, and from enhancement of the recreational opportunities in the area. Some minor flood control benefits would accrue from operation of the proposed reservoirs even though specific flood control features were not included. However, incidental benefits were not evaluated and economic justification was based solely on hydroelectric power, irrigation, and recreational benefits.

Hydroelectric power benefits would be realized from the operation of the Meadow Valley Power Plant and from the existing Rock Creek, Cresta, and Poe Power Plants of the Pacific Gas and Electric Company on the North Fork.

TABLE 39

GENERAL FEATURES OF NELSON POINT-MEADOW VALLEY-NORTH FORK PLAN

Dam and reservoir	Stream	Dam: Location MDB&M	Dam: Type 1/	Dam: Height, in feet	Dam: Crest length, in feet	Water surface elev., in feet: Normal pool	Water surface elev., in feet: Minimum pool	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active
Nelson Point	M.F. Feather River	Sec18, T23N, R10E	CA	365	900	4,030	3,850	116,000	104,000
Meadow Valley	Spanish Creek	Sec17, T24N, R9E	E	464	1,900	3,924	3,680	900,000	855,000
Red Ridge Diversion	Bear Creek	Sec16, T23N, R8E	CG	25	100	4,317	---	---	---

Power Plant	Location MDB&M	Maximum gross static head in feet	Minimum gross static head in feet	Average head loss, in feet	Installed capacity, in kilowatts	Dependable capacity, in kilowatts	Average seasonal energy, in megawatt-hours	Peak flow, in second-feet	Head-water elevation, in ft.	Tail-water elevation, in feet
Meadow Valley	Sec19, T25N, R7E	1,709	1,465	145	118,500	118,500	506,000	1,250	3,924	2,215

Tunnel	Capacity in second-feet	Diameter, in feet: Lined	Diameter, in feet: Unlined	Cross section	Percentage lined	Length, in feet
Nelson Point-Meadow Valley	3,700	14.0	---	Circular	100	41,000
Meadow Valley-North Fork	1,250	12.25	---	Circular	100	51,000
Red Ridge-Meadow Valley	570	7.0	---	Horseshoe	100	19,000

1/ Type
E = Earthfill
CA= Concrete arch
CG= Concrete gravity

TABLE 40

SUMMARY OF ESTIMATED COSTS OF
NELSON POINT-MEADOW VALLEY-NORTH FORK PLAN

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$ 104,029,000
Lands, easements, and rights of way	1,850,000
Relocation of public utilities	1,683,000
Subtotal	$ 107,562,000
Engineering and administration	$ 10,894,000
Contingencies	15,716,000
Interest during construction	9,202,000
TOTAL CAPITAL COST	$ 143,374,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 6,674,000
Operation and maintenance, replacement, general expense, and insurance	1,066,000
Taxes foregone	1,003,000
Subtotal	$ 8,743,000
Recreation features	
Public facilities, including operation and maintenance	$ 183,000
TOTAL ANNUAL COST	$ 8,926,000

The increase in power output from the existing plants of the Pacific Gas and Electric Company would be made possible by diversion of additional water into the North Fork. The estimated average annual benefits would be about $4,091,000 from Meadow Valley Power Plant and about $1,008,000 from the existing power plants of the Pacific Gas and Electric Company.

Irrigation benefits, estimated at $1,064,000 per season, would be realized from the estimated 133,000 acre-feet of new water that would be made available for irrigation by the project.

Recreational benefits would accrue to the project from enhancement of the Nelson Point and Meadow Valley reservoir areas and from the Middle Fork Canyon area. Only those recreational benefits estimated to be derived from public recreational facilities were evaluated for the study. The estimated net annual recreational benefits would be $110,000 from the Nelson Point Reservoir, $193,000 from Meadow Valley Reservoir, and $141,000 from the Middle Fork Canyon. The derivation of these benefits is discussed in detail in Appendix A.

Total estimated benefits from all sources for the Nelson Point-Meadow Valley-North Fork Plan are summarized in Table 41.

TABLE 41

ESTIMATED AVERAGE ANNUAL NET BENEFITS
FROM THE NELSON POINT-MEADOW VALLEY-NORTH FORK PLAN

Item	Benefit
Hydroelectric power	$5,099,000
Irrigation	1,064,000
Recreation	444,000
TOTAL	$6,607,000

The resulting ratio of benefits to costs for the Nelson Point-Meadow Valley-North Fork Plan would be 0.74 to 1 (1959).

Nelson Point-Meadow Valley-Bald Rock Plan

This project would include the construction of Nelson Point Reservoir on the Middle Fork of the Feather River, the diversion of the conserved waters for storage in Meadow Valley Reservoir on Spanish Creek, and the diversion of the conserved water from Meadow Valley Reservoir back to the Middle Fork together with the diversion of additional waters from Bear Creek to pass through three power plants. In addition to the regulated water, the lower two power plants would receive significant amounts of water from uncontrolled runoff from local drainage areas.

Monthly yield studies, based on the estimated available runoff, were conducted in sizing the project. A summary of the yield study for the size of project selected is presented in Appendix B.

The Nelson Point-Meadow Valley-Bald Rock Plan would produce an estimated 168,000 acre-feet of new, firm, irrigation water seasonally. This estimate was based on conditions expected to prevail in the future, when water supplies available to the project would have been reduced by an amount necessary to meet requirements for upstream use.

It was estimated that the project would have an installed power capacity of 220,000 kilowatts, a dependable power capacity of 209,000 kilowatts, and would produce about 1,150,000,000 kilowatt-hours of energy seasonally. Also, because of the diversion of the waters of Spanish Creek away from the existing Rock Creek, Cresta, and Poe Power Plants of the Pacific Gas and Electric Company, it was estimated that there would be a reduction of about 80,000,000 kilowatt-hours seasonally in the amount of energy produced by these plants.

The project would provide new recreational opportunities and would enhance outdoor recreation by providing a setting for the development of camp sites, boating facilities, and summer homes. Both the area surrounding the reservoirs and the Middle Fork canyon area are attractive for this type of development.

Location of the project is shown on Plate 10, "Alternative Middle Fork Plans, Clio-Nelson Point-Swayne Plan and Nelson Point-Meadow Valley-Bald Rock Plan".

Under the plan of development, Nelson Point Reservoir, with a storage capacity of 116,000 acre-feet, would be created by construction of a concrete arch dam 365 feet in height about three miles downstream from the junction of Nelson Creek with the Middle Fork in Section 18, Township 23 North, Range 9 East, MDB&M. The regulated flow from Nelson Point Reservoir would be released through a tunnel 7.8 miles in length for storage in Meadow Valley Reservoir on Spanish Creek. This reservoir with a storage capacity of 900,000 acre-feet, would be created by construction of a zoned earthfill dam 464 feet in height about three miles west of Quincy, in Section 17, Township 24 North, Range 9 East, MDB&M. The regulated flow from Meadow Valley Reservoir would be conveyed through a tunnel 12.0 miles in length to the Meadow Valley Power Plant. This plant would have an installed power capacity of 85,000 kilowatts, and would be located in Section 11, Township 22 North, Range 7 East, MDB&M. Enroute, the Meadow Valley Power Plant tunnel would intercept the flows of Bear Creek at the Red Ridge diversion works. Red Ridge diversion works would be created by construction of a concrete gravity dam 25 feet in height on Bear Creek in Section 16, Township 23 North, Range 8 East, MDB&M. Hartman Bar Dam on the Middle Fork of the Feather River with a height of 90 feet, would be constructed to form a reregulating reservoir below the Meadow Valley Power Plant. This dam would be of concrete arch construction and would be located 0.4 mile downstream from the junction of Willow Creek and the Middle Fork in Section 11, Township 22 North, Range 7 East, MDB&M. From Hartman Bar

Dam, a tunnel 7.7 miles in length would convey the water for discharge through Hartman Bar Power Plant. This plant, with installed power capacity of 55,000 kilowatts, would be located at Milsap Bar, in Section 2, Township 21 North, Range 6 East, MDB&M. Bald Rock Dam would have a height of 180 feet, would be of concrete arch design, and would be located about one-half mile downstream from American Bar in Sections 10, 11 and 14, Township 21 North, Range 6 East, MDB&M. It would be constructed to form a reregulating reservoir below Hartman Bar Power Plant. From Bald Rock Dam, a tunnel 3.0 miles in length would extend to Bald Rock Power Plant. This plant, with an installed power capacity of 80,000 kilowatts, would be located at the junction of Fall Creek and the Middle Fork of the Feather River, in Section 35, Township 21 North, Range 6 East, MDB&M. The project as described would have a total installed power capacity of 220,000 kilowatts.

The geologic investigations of the dam sites proposed in the Nelson Point-Meadow Valley-Bald Rock Plan consisted of a review of available reports and of a foundation exploration program at the Meadow Valley dam site. In addition, field reconnaissances were made of the dam sites located on the Middle Fork of the Feather River. The results of these studies were presented previously herein under the discussion of the Modified Richvale Plan and the Nelson Point-Meadow Valley-North Fork Plan.

The geologic investigation of the tunnel routes included in the Nelson Point-Meadow Valley-Bald Rock Plan consisted of a review of available reports and a brief field reconnaissance of the routes.

A discussion of the geologic conditions of all tunnel routes, except the Meadow Valley-Hartman Bar Route, has been described previously herein. The geologic conditions of the tunnel routes are shown on Plate 11.

The intake portal of the Meadow Valley-Hartman Bar tunnel would be located near the confluence of Meadow Valley Creek and Rock Creek. An open channel or a large cut and cover conduit with a length of about one-half mile would be constructed to the intake portal. The bedrock in this area is serpentine. Heavy support and lining would be required for about 2.25 miles, the minimum distance of tunnel in serpentine. After leaving the serpentine, the tunnel would penetrate the Calaveras formation. In this formation, the alignment would be in a southerly direction toward the Red Ridge diversion site. The Calaveras formation in this area has been sheared and faulted, and the rock should be classified as very blocky and seamy. Support would be moderately heavy and lining almost continuous. Water under high pressure in shear zones should be anticipated. The bore would penetrate about two miles of the Calaveras formation before entering granodiorite. The granodiorite near the contact would be sheared, possibly even crushed. Thus, heavy support and lining would be required.

The engineering designs of the features of the Nelson Point-Meadow Valley-Bald Rock Plan were of a preliminary nature. Additional field exploration and study may develop information that substantially could change the designs and estimates of cost presented herein. The designs of the Nelson Point, Hartman Bar, and Bald Rock Dams as developed by the Richvale Irrigation District were utilized for the purposes of this study.

Pertinent data with respect to general features of the Nelson Point-Meadow Valley-Bald Rock Project, as designed for preliminary cost estimating purposes, are presented in Table 42.

The economic analysis of the Nelson Point-Meadow Valley-Bald Rock Plan consisted of a preliminary determination of the economic justification of the project. This work entailed a comparison of the estimated project benefits and costs to determine the overall project benefit-cost ratio.

TABLE 42

GENERAL FEATURES OF NELSON POINT-MEADOW VALLEY-BALD ROCK PLAN

Dam and reservoir	Stream	Dam: Location MDB&M	Dam: Type 1/	Dam: Height, in feet	Dam: Crest length, in feet	Water surface elev. in feet: Normal pool	Water surface elev. in feet: Minimum pool	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active
Nelson Point	M.F. Feather River	Sec18, T23N, R10E	CA	365	900	4,030	3,850	116,000	104,000
Meadow Valley	Spanish Creek	Sec17, T24N, R9E	E	464	1,900	3,924	3,680	900,000	855,000
Hartman Bar	M.F. Feather River	Sec11,	CA	90	355	2,320	---	---	---
Bald Rock	M. F. Feather River	11,14 T21N R6E							
			CA	180	405	1,580	---	---	---
Red Ridge Div.	Bear Creek	Sec16, T23N R8E	CG	25	100	4,317	---	---	---

Power Plant	Location MDB&M	Maximum gross static head, in feet	Minimum gross static head, in feet	Average head loss, in feet	Installed capacity in kilowatts	Dependable capacity, in kilowatts	Average seasonal energy, in megawatt-hours	Peak flow, in second feet	Head-water elevation, in feet	Tail-water elevation, in feet
Meadow Valley	Sec11, T22N, R7E	1,604	1,360	125	85,000	---		984	3,924	2,320
Hartman Bar	Sec 2, T21N, R6E	740	740	90	55,000	209,000	1,150,000	1,175	2,320	1,580
Bald Rock	Sec35, T21N, R6E	680	680	40	80,000	---		1,735	1,580	900
Total system		3,024	2,780	255	220,000	209,000	1,150,000			

Tunnel	Capacity, in second-feet	Diameter, in feet: Lined	Diameter, in feet: Unlined	Cross section	Percentage: lined	Length, in feet
Nelson Point-Meadow Valley	3,700	14.0		Circular	100	41,000
Meadow Valley-Meadow Valley P.H.	984	11.25		Circular	100	63,200
Hartman Bar-Milsap Bar	1,175	13,25	15.5	Horseshoe	48	40,600
Bald Rock	1,735	16.0	18.5	Horseshoe	20	15,900

1/ Type:
E = Earthfill
CA= Concrete arch
CG =Concrete gravity

The capital cost of the project was estimated at $190,990,000. The corresponding annual costs, using an interest rate of 4.6 percent per annum and an amortization period of 50 years, were estimated to be about $12,614,000. Of this amount, the estimated annual value of taxes foregone is about $1,861,000. An estimate of costs of individual project features is presented in Appendix C. A summary of capital and annual costs, and of taxes foregone is presented in Table 43.

The benefits that would accrue to the Nelson Point-Meadow Valley-Bald Rock Plan would result from production of hydroelectric power, from new irrigation water supplies, and from enhancement of recreational opportunities. Some minor flood control benefits would accrue from operation of the proposed reservoirs even though specific flood control features were not included. However, incidental benefits were not evaluated and economic justification was based solely on hydroelectric power, irrigation, and recreation benefits.

Hydroelectric power benefits would be realized from the operation of the three power plants of the project. Also, there would be a decrease in benefits from the existing Rock Creek, Cresta, and Poe Power Plants of the Pacific Gas and Electric Company because of the flows of Spanish Creek being diverted away from these plants. The estimated average annual power benefits would be about $7,968,000 from the three power plants of the project.

The value of the decrease in energy produced by the power plants of the Pacific Gas and Electric Company was estimated at $233,000 seasonally.

Irrigation benefits would be realized from the estimated 168,000 acre-feet of new firm water that would be made available for irrigation from the operation of the project. The estimated irrigation benefits would be $1,344,000 seasonally.

TABLE 43

SUMMARY OF ESTIMATED COSTS OF
NELSON POINT-MEADOW VALLEY-BALD ROCK PLAN

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$ 140,550,000
Lands, easements, and rights of way	1,850,000
Relocation of public utilities	1,683,000
Subtotal	$ 144,083,000
Engineering and administration	$ 14,574,000
Contingencies	21,109,000
Interest during construction	11,223,000
TOTAL CAPITAL COST	$ 190,989,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 8,891,000
Operation and maintenance, replacement, general expense, and insurance	1,686,000
Taxes foregone	1,861,000
Subtotal	$ 12,438,000
Recreation features	
Public facilities, including operation and maintenance	$ 176,000
TOTAL ANNUAL COST	$ 12,614,000

Irrigation benefits would be realized from the estimated 168,000 acre-feet of new firm water that would be made available for irrigation from the operation of the project. The estimated irrigation benefits would be $1,344,000 seasonally.

Recreation benefits would accrue to the project from enhancement of the Nelson Point and Meadow Valley Reservoir areas and from the Middle Fork canyon area below Nelson Point Reservoir. Only those recreational benefits estimated to be derived from public recreational facilities were evaluated for this study. The estimated net annual recreational benefits would be $110,000 fcr Nelson Point Reservoir, $193,000 for Meadow Valley Reservoir, and $120,000 for the Middle Fork canyon area. The derivation of these benefits is discussed in detail in Appendix A.

Total estimated average annual benefits from all sources for the Nelson Point-Meadow Valley-Bald Rock Plan total $9,500,000 and are summarized in Table 44.

TABLE 44

ESTIMATED AVERAGE ANNUAL NET BENEFITS FOR THE NELSON POINT-MEADOW VALLEY-BALD ROCK PLAN

Item	Benefit
Hydroelectric power	$7,735,000
Irrigation	1,344,000
Recreation	423,000
TOTAL	$9,502,000

The resulting ratio of benefits to costs for the Nelson Point-Meadow Valley-Bald Rock Plan would be 0.75 to 1 (1959).

Turntable-Meadow Valley-Swayne Plan

This project would include the construction of Turntable Reservoir on Middle Fork of the Feather River and the diversion of the water from Turntable Reservoir for storage in Meadow Valley Reservoir on Spanish Creek. From Meadow Valley Reservoir, the conserved water, augmented by a diversion from Bear Creek, would be conveyed to a power plant located at Hartman Bar on the Middle Fork of the Feather River. Downstream from the power plant, Hartman Bar Reservoir would be constructed to reregulate the releases from the power plant. From Hartman Bar Reservoir, the conserved water, augmented by a diversion from the Little North Fork, would be conveyed by tunnel for storage in the proposed Swayne Reservoir on French Creek. From this reservoir, the conserved water would be conveyed to a power plant located on lower French Creek on the shore of Oroville Reservoir.

Monthly yield studies, based on the estimated available runoff used in sizing the project, are summarized in Appendix B.

The project would produce a new firm irrigation yield estimated at 191,000 acre-feet seasonally. This estimate was based on conditions expected to prevail in the future, when water supplies available to the project would have been reduced to meet requirements of upstream use.

It was estimated that the project would have an installed power capacity of 273,000 kilowatts, a dependable power capacity of 273,000 kilowatts, and would produce 1,301,700,000 kilowatt-hours of energy seasonally. Because the project would divert the waters of Spanish Creek away from the existing Rock Creek, Cresta and Poe Power Plants of the Pacific Gas and Electric Company on the North Fork, a seasonal reduction would occur of 73,400,000 kilowatt-hours in the generation of energy in those plants.

The project would enhance outdoor recreation by providing a setting for the development of camp sites, boating facilities and summer homes. Both the area surrounding the proposed reservoirs and the Middle Fork canyon area are attractive for this type of development. Location of the project is shown on Plate 9, "Alternative Middle Fork Plans and Turntable-Meadow Valley-Swayne Plan".

Under the plan of development, Turntable Reservoir with a storage capacity of about 47,800 acre-feet, would be created by construction of a zoned rockfill dam with a height of 245 feet just downstream from the junction of Nelson Creek with the Middle Fork in Section 16, Township 23 North, Range 10 East, MDB&M. The regulated water from Turntable Reservoir would be released through a tunnel 10.0 miles in length for storage in Meadow Valley Reservoir on Spanish Creek. This reservoir with a storage capacity of 900,000 acre-feet, would be created by construction of a zoned earthfill dam 464 feet in height about three miles west of Quincy, in Section 17, Township 24 North, Range 9 East, MDB&M. Regulated water from Meadow Valley Reservoir, augmented by a diversion from Bear Creek at the Red Ridge site would be released through a tunnel 10.8 miles in length, to pass through Meadow Valley Power Plant located at Hartman Bar. This plant would have an installed power capacity of 98,000 kilowatts, and would be located in Section 1, Township 22 North, Range 7 East, MDB&M. Red Ridge diversion works would be created by construction of a concrete gravity dam 25 feet in height on Bear Creek in Section 16, Township 23 North, Range 8 East, MDB&M. Hartman Bar Dam with a height of 175 feet would be constructed to form a reregulating reservoir below the Meadow Valley Power Plant.

This dam would be of concrete arch construction and would be located 0.4 mile downstream from the junction of Willow Creek on Middle Fork of Feather River in Section 11, Township 22 North; Range 7 East, MDB&M. From Hartman Bar Dam, the conserved water would be conveyed by tunnel 6.4 miles in length to Spoon diversion works located on the Little North Fork in Section 27, Township 22 North, Range 6 East, MDB&M. Spoon diversion dam would be of concrete gravity construction with a height of 25 feet. From Spoon diversion works, 1.8 miles of tunnel would convey the regulated water for storage in Swayne Reservoir on French Creek. Swayne Dam would be of earthfill construction with a height of 380 feet and would be located about three miles upstream from the confluence of French Creek with the North Fork of the Feather River in Section 35, Township 22 North, Range 5 East, MDB&M. From Swayne Reservoir, a tunnel 1.3 miles in length would convey the regulated water to Swayne Power Plant. This plant, with an installed capacity of 175,000 kilowatts, would be located on French Creek about one mile upstream from its confluence with the North Fork of the Feather River in Section 10, Township 21 North, Range 5 East, MDB&M. The project as described would have a total installed capacity of 273,000 kilowatts.

Except for the Turntable dam site, the geologic conditions of the dam sites have been discussed previously herein.

The exploration program at the Turntable site included surface geologic mapping of the dam site, preliminary test drilling of the foundation and spillway areas, petrographic analysis of the foundation rock, collection of soil samples, and estimation of quantities of available construction materials.

Subsurface foundation exploration included a total of 1,036 lineal feet of core holes.

Topography at Turntable dam site is characterized by steep, rocky slopes which form a narrow gorge. Slopes up to 100 percent are common. Bedrock at the site consists of contorted, thin-bedded slate, phyllite, and quartzite with occasional thick beds of quartzite and limestone. The thickness of these beds varies from a few inches to several feet. Bedrock outcrops are prominent near the channel. The strike of the beds is N30°W, which is roughly parallel to the proposed axis of the dam. The dip of the beds is nearly vertical.

A large zone of discontinuous bedding-plane shears is exposed on the right abutment. This shear zone is 180 feet wide on the upper part of the right abutment, but thins to about 40 feet near the channel.

A portion of the left abutment, located in the vicinity of the spillway approach area, has slumped badly & appears unstable. The rock in this area is badly fractured and often powdered and, therefore, would have to be removed. The spillway crest and channel would be located on firmer bedrock.

Based on present data, stripping of the right abutment beneath the impervious section should consist of an average of about six feet of talus and soil, plus six feet of weathered bedrock. About three feet of soil cover should be stripped beneath the pervious section. On the left abutment, an average of about 10 feet of slumped and weathered rock should be removed beneath the impervious section, and an average of five feet beneath the pervious section.

Water tests indicated severe leakage across the entire axis. However, with an adequate grout program and because of the favorable attitude of the beds along the axis, leakage beneath a dam at this site should not be excessive. It is anticipated that the grout take would be moderate to heavy.

Impervious material for use in the core of a dam could be obtained at Texas Flat, located 0.3 mile upstream from the site. Spoil from the large spillway cut could be used in the random fill section of the dam. Limestone, quarried and crushed from Limestone Point about 1.5 miles downstream from the site, could be used for pervious material or rock fill.

Exploration of the bedrock has shown that Turntable dam site is not ideal from a geologic point of view. Thin-bedded rocks together with sheared zones provide rather poor foundation conditions. Heavy slumpage in the bedrock in the proposed spillway approach area is a serious problem. However, Turntable dam site is considered suitable for a properly constructed zoned earthfill dam with a height of up to 250 feet. Geologic conditions at the Turntable site are shown on Plate 15, entitled "Turntable Dam on Middle Fork Feather River".

The geologic investigation of the tunnel routes included in the Turntable-Meadow Valley-Swayne Plan consisted of a review of published data and a brief field reconnaissance of the routes. The geologic conditions of tunnel routes have been described previously herein.

The engineering designs of the Turntable-Meadow Valley-Swayne Plan were of a preliminary nature. Additional field exploration and study may develop information that substantially could change the designs and estimates of costs presented herein. Pertinent data with respect to general features of the Turntable-Meadow Valley-Swayne Plan, as designed for preliminary cost estimating purposes, are presented in Table 45.

TABLE 45

GENERAL FEATURES OF TURNTABLE-MEADOW VALLEY-SWAYNE PLAN

Dam and reservoir	Stream	Dam: Location MDB&M	Dam: Type1/	Dam: Height, in feet	Dam: Crest length, in feet	Water surface elevation, in ft.: Normal pool	Water surface elevation, in ft.: Minimum pool	Storage capacity in acre-feet: Gross	Storage capacity in acre-feet: Active
Turntable	M.F. Feather River	Sec16, T23N, R10E	R	245	900	4,024	3,910	47,800	43,700
Meadow Valley	Spanish Creek	Sec17, T24N, R9E	E	464	1,900	3,924	3,680	900,000	855,000
Red Ridge Diversion	Bear Creek	Sec16, T23N, R8E	CG	25	100	4,317	---	---	---
Hartman Bar	M.F. Feather River	Sec11, T22N, R7E	CA	175	600	2,405	---	---	---
Spoon Diversion	Little North Fork	Sec27, T22N, R6E	CG	25	150	2,345	---	---	---
Sqayne	French Creek	Sec35, T22N, R5E	E	380	2,700	2,330	2,095	280,000	262,000

Power Plant	Location MDB&M	Maximum gross static head, in feet	Minimum gross static head, in feet	Average head loss, in feet	Installed capacity, in kilowatts	Dependable capacity, in kilowatt	Average annual energy, in kilowatt-hours	Peak flow, sec.-feet	Head-water elev., in ft.	Tail-water elev., in feet
Meadow Valley	Sec 1, T22N, R7E	1,501	1,255	125	98,000	98,000	450,000,000	1,200	3,924	2,405
Swayne	Sec10, T21N, R5E	1,430	1,195	46	175,000	175,000	600,000,000	2,100	2,330	900
Total system		2,931	2,450		273,000	273,000	1,050,000,000			

Tunnel	Capacity, in second-feet	Diameter in feet: Lined	Diameter in feet: Unlined	Cross section	Percentage lined	Length, in feet
Turntable-Meadow Valley	3,150	14.0		Circular	100	52,800
Meadow Valley-Hartman Bar P.H.	1,200	12.5		Circular	100	62,300
Hartman Bar-Spoon	1,500	14.75	17.25	Horseshoe	67	34,100
Spoon-Swayne	1,800	16.5	19.25	Horseshoe	47	9,400
Swayne-Swayne P.H.	2,100 2/	14.33		Circular	100	6,800

1/ Type:
R = Rockfill
E = Earthfill
CA= Concrete arch
CG= Concrete gravity

2/ 5,200 second-feet for stream diversion during dam construction.

The economic analysis of the Turntable-Meadow Valley-Swayne Plan consisted of a preliminary determination of economic justification of the project. This entailed a comparison of the estimated project benefits and costs to determine the overall project benefit-cost ratio.

The capital cost of the Turntable-Meadow Valley-Swayne Plan was estimated at $233,483,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years and including operation, maintenance and replacement were estimated to be about $15,238,000. Of this amount, the estimate of the annual value of taxes foregone is $2,310,000. An estimate of the costs of individual project features is presented in Appendix C. A summary of capital and annual costs and of the cost of taxes foregone is presented in Table 46.

The benefits that would accrue to the Turntable-Meadow Valley-Swayne Plan would result from production of hydroelectric power, irrigation from new water supplies and from enhancement of recreational opportunities in the area. Some minor flood control benefits would accrue from operation of the proposed reservoirs, even though specific flood control features were not included. However, incidental benefits were not evaluated and economic justification was based solely on hydroelectric power, irrigation and recreational benefits.

Hydroelectric power benefits would be realized from the operation of the Meadow Valley and Swayne Power Plants. However, there would be a decrease in power benefits from the existing Rock Creek, Cresta and Poe Power Plants of the Pacific Gas and Electric Company as a result of the flows of Spanish Creek being diverted away from these plants. The estimated average annual power benefits would be about $9,825,000. from the power plants of the project. The value of the decrease in power benefits from the power plants of the Pacific Gas and Electric Company was estimated at $213,000. seasonally.

TABLE 46

SUMMARY OF ESTIMATED COSTS OF
TURNTABLE-MEADOW VALLEY-SWAYNE PLAN

(Based on prices prevailing in fall of 1958)

Item	Cost
CAPITAL COST	
Project construction	$ 173,789,000
Lands, easements, and rights of way	2,066,000
Relocation of public utilities	765,000
Subtotal	$ 176,620,000
Engineering and administration	$ 17,811,000
Contingencies	26,045,000
Interest during construction	13,007,000
TOTAL CAPITAL COST	$ 233,483,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 10,869,000
Operation and maintenance, replacement, general expense, and insurance	1,861,000
Taxes foregone	2,310,000
Subtotal	$ 15,040,000
Public recreational facilities, including operation and maintenance	$ 198,000
TOTAL ANNUAL COST	$ 15,238,000

Irrigation benefits would be realized from the estimated 191,000 acre-feet of new firm water for irrigation estimated at $1,528,000 seasonally.

Recreation benefits would accrue to the project from enhancement of the Turntable, Meadow Valley, and Swayne Reservoir areas and from the Middle Fork canyon area below Turntable Reservoir. Only those recreational benefits estimated to be derived from public recreational facilities were evaluated for this study. The estimated net annual recreational benefits would be $110,000 for Turntable Reservoir, $193,000 for Meadow Valley Reservoir, $49,000 for Swayne Reservoir, and $140,000 for the Middle Fork canyon area. The derivation of these benefits is discussed in detail in Appendix A.

Total estimated benefits from all sources for the Turntable-Meadow Valley-Swayne Plan are summarized in Table 47.

TABLE 47

ESTIMATED AVERAGE ANNUAL NET BENEFITS FOR THE TURNTABLE-MEADOW VALLEY-SWAYNE PLAN

Item	Benefit
Hydroelectric power	$ 9,612,000
Irrigation	1,528,000
Recreation	492,000
TOTAL	$11,632,000

The resulting ratio of benefits to costs for the Turntable-Meadow Valley-Swayne Plan would be 0.76 to 1 (1959).

Plans for Development of the North Fork of the Feather River

The water resources of the main stem of the North Fork of the Feather River have been extensively developed for the production of hydroelectric power by the Pacific Gas and Electric Company. In the remainder of the North Fork Basin, possibilities exist for storage of unregulated waters for irrigation use, for enhancement of fishing and recreational uses, for flood control, and for the production of hydroelectric power.

Three potential projects for developing the waters of the Indian Creek portion of the North Fork Basin were studied during the Upper Feather River Basin Investigation. As previously stated herein, one of the projects, the Indian Creek Recreation Project, has been authorized as part of the Feather River Project. The department is currently engaged in advance planning studies of this project. These studies include a re-evaluation of the costs and accomplishments of the project. The other two projects, the Squaw Queen and the Genesee Recreation Projects, were studied as possible future developments.

Indian Creek Recreation Project

The following discussion of the Indian Creek Recreation Project was summarized from Bulletin No. 59. The Indian Creek Recreation Project would comprise a system of works for regulating the waters of Indian Creek and its tributaries for the enhancement of the recreational potential of the upper Indian Creek Basin. The project would include Antelope Valley Reservoir on Indian Creek, Dixie Refuge Reservoir on Last Chance Creek, and Abbey Bridge Reservoir on Red Clover Creek. It was estimated that an average annual increase of 93,200 visitor-days of use over and above the present use would be realized from developments around the reservoirs included in the Indian Creek Recreation Project. In addition, about 309,000 visitor-days of use would be realized from

62 miles of streams that would be improved by the operation of the project. Features of the authorized Indian Creek Recreation Project are shown on Plate 6.

Antelope Valley Reservoir. Antelope Valley Reservoir would be created by construction of an earthfill dam with a height of 93 feet on Indian Creek about one mile downstream from the Boulder Creek Guard Station. The reservoir would have a gross storage capacity of 21,600 acre-feet and a net capacity of 18,300 acre-feet. The water surface area at spillway crest elevation of 5,000 feet would be 930 acres.

Dixie Refuge Reservoir. Dixie Refuge Reservoir would be created by construction of an earthfill dam with a height of 81 feet on Last Chance Creek about five miles south of Milford. The reservoir would have a gross storage capacity of 16,100 acre-feet and a net storage capacity of 14,150 acre-feet. The water surface area at spillway crest elevation of 5,740 feet would be 800 acres.

Abbey Bridge Reservoir. Abbey Bridge Reservoir would be created by construction of an earthfill dam with a height of 71 feet on Red Clover Creek about two miles upstream from the Abbey Bridge Guard Station. The reservoir would have a gross storage capacity of 11,100 acre-feet and a net storage capacity of 10,100 acre-feet. The water surface area at spillway crest elevation of 5,420 feet would be 540 acres.

Squaw Queen Project

Squaw Queen Project would include Squaw Queen Dam and Reservoir on Last Chance Creek and a conduit system for conveying the conserved waters for discharge through a power plant located upstream from the junction of Last Chance and Red Clover Creeks in Genesee Valley. Waters released through the power plant would be reregulated in the potential Genesee Reservoir, the principal feature of the Genesee Recreation Project.

Under the plan of operation, the releases for stream flow maintenance purposes from the upstream Dixie Refuge Reservoir on Last Chance Creek would pass through Squaw Queen Reservoir to the stream channel below the dam. The Squaw Queen Project would have an installed power capacity of 12,000 kilowatts, a dependable power capacity of 11,300 kilowatts, and would produce 56,570,000 kilowatt-hours of energy seasonally. In addition, the regulated waters from the project would increase the production of energy from the existing Rock Creek, Cresta, and Poe Power Plants of the Pacific Gas and Electric Company by 12,500,000 kilowatt-hours seasonally.

New recreational opportunities would be made available by the project by providing a setting for the development of camp sites, boating facilities, and summer homes. Location of the project is shown on Plate 6.

Squaw Queen Dam would be located on Last Chance Creek about 1.5 miles downstream from the junction of Last Chance and Squaw Queen Creeks in Sections 1 and 2, Township 25 North, Range 12 East, MDB&M. A topographic map of the dam site and reservoir area at a scale of one inch equals 400 feet and a contour interval of 10 feet was made in 1957. Reservoir area and capacity data taken from this map are presented in Table 48.

The geologic investigation of the Squaw Queen dam site was limited to reconnaissance geologic mapping and borrow material sampling. The site is located in a granitic gorge of Last Chance Creek well below a contact between granitic basement rocks and overlying andesitic and basaltic lava flows. The granitic rocks at the site are very uniform and consistent. They are massive, coarse-grained, and hard, except near the surface and along joints where weathering is more active. Width of weathering along joints probably diminishes rapidly with depth. Good exposures of rock are present along the channel section.

TABLE 48

AREAS AND CAPACITIES OF SQUAW QUEEN RESERVOIR

Depth of water at dam, in feet	Water surface elevation, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	5,290	0	0
30	5,320	40	500
70	5,360	120	3,500
110	5,400	520	14,300
150	5,440	1,440	51,500
190	5,480	3,450	146,000

A saddle behind the right abutment appears to be a satisfactory location for a spillway. However, this spillway site is within a few hundred feet of a recently active fault and it appears to be near the intersection of two well-developed shear zones. The overburden of decomposed granitic rock apparently is quite deep in the saddle area. Lining of the spillway channel may be required to prevent erosion. Sufficient amounts of impervious, semi-pervious, and rockfill materials are located within three miles of the dam site, and could be used for the construction of the dam.

Earthquakes centered on faults northeast and southeast of Diamond Mountain in 1908 and 1951, and evidence of recent faulting near the dam site indicate moderate to high seismicity in this area. Based on preliminary geologic reconnaissance, Squaw Queen dam site appears to be suitable for the construction of a zoned earth or rockfill dam. Geologic conditions of the Squaw Queen dam site are shown on Plate 17, "Squaw Queen Dam on Last Chance Creek".

The average seasonal runoff from the approximately 200 square miles of watershed above the Squaw Queen dam site is estimated at 63,000 acre-feet. Reservoir operation studies and consideration of topographic and geologic conditions, led to the selection of a reservoir with a storage capacity of 100,000 acre-feet for cost analyses of the Squaw Queen Project.

The dam would be of zoned earth and rock construction with a height of 184 feet, a crest length of 760 feet, and side slopes of 2:1. The spillway would be located in a saddle about 700 feet west of the right abutment of the dam. It would have a concrete weir 100 feet in length from which discharges would be made into an unlined trapezoidal channel. The unlined channel would connect with Last Chance Creek about 0.5 mile downstream from the dam.

The outlet works were designed to make releases both for stream flow maintenance and for power production. The submerged inlet structure would contain two 36-inch diameter valves connected to a 76-inch diameter concrete pipe. Just downstream from the dam an 18-inch discharge valve in a control valve house would release water for stream flow maintenance. From this valve house, a concrete pipe line with a diameter of 60 inches and a length of 24,500 feet, plus 900 feet of tunnel, would extend to the penstock leading to the power plant. The capacity of the conduit would be 100 second-feet. The penstock would be 36 inches in diameter and would lead to a power plant with an installed capacity of 12,000 kilowatts located at the upper end of Genesee Valley. The general features of the Squaw Queen Project and related data are presented in Table 49.

Most of the land in the Squaw Queen reservoir site is in the Plumas National Forest. Several United States Forest Service roads would be inundated by the reservoir. Timber covers most of the area and much of it would be salvageable.

A preliminary determination of the economic justification of the Squaw Queen Project was made. This work entailed a comparison of the estimated project benefits and costs to determine the project benefit-cost ratio.

The capital cost of the total project was estimated to be about \$9,412,000. Corresponding annual costs, using an interest rate of 4.0 percent

TABLE 49

GENERAL FEATURES OF SQUAW QUEEN PROJECT

Dam Site	
Location	Sec. 1 & 2, T25N, R12E, MDB&M
Stream	Last Chance Creek
Dam	
Type	composite-earth & rockfill
Crest elevation, in feet	5,474
Crest, length in feet	760
Crest width, in feet	25
Height above stream bed, in feet	184
Freeboard, in feet	9.5
Side slopes	
Upstream	2:1
Downstream	2:1
Elevation of stream bed, in feet	5,290
Volume of fill, in cubic yards	1,100,000
Reservoir	
Water surface elevation at normal pool, in feet	5,464.5
Surface area at spillway crest, in acres	2,550
Storage capacity at spillway crest, in acre-feet	100,000
Drainage area, in square miles	198
Average seasonal runoff, in acre-feet	63,000
Seasonal yield of water, in acre-feet	40,000
Type of spillway	Ogee weir with trapezoidal chute
Spillway discharge capacity, in second-feet	5,060
Type of outlet works	reinforced-concrete cut-and-cover conduit
Pipeline	
Type	Low-pressure concrete pipe
Length, in feet	24,500
Diameter, in feet	5.0
Tunnel	
Type	concrete-lined, circular
Length, in feet	900
Diameter, in feet	7.0
Power Plant	
Installed capacity, in kilowatts	12,000
Average annual energy produced, in kilowatt-hours	56,570,000

per annum and an amortization period of 50 years were estimated to be $761,000. Of this amount, the estimated annual value of taxes foregone is about $101,000. An estimate of costs of individual project features is presented in Appendix C. A summary of capital and annual costs and of taxes foregone are presented in Table 50.

The benefits that would accrue to the Squaw Queen Project would result from production of hydroelectric power and from enhancement of recreation opportunities in the area. Some minor flood control benefits would accrue from operation of the reservoir even though specific flood control features were not included. However, incidental flood control benefits were not evaluated and economic justification was based solely on benefits from production of electrical energy and from recreation.

Hydroelectric power benefits would be realized from the operation of the Squaw Queen Power Plant and as a result of the incremental increase in power generated by the existing Rock Creek, Cresta, and Poe Power Plants of the Pacific Gas and Electric Company. This increment of power output would be made possible by improved flow conditions in the North Fork resulting from the operation of Squaw Queen Reservoir. The estimated average seasonal power benefits would be about $415,000 from the operation of Squaw Queen Power Plant and $37,000 from the existing plants of the Pacific Gas and Electric Company.

Recreational benefits would accrue to the Squaw Queen Project from enhancement of the reservoir area. Only those recreational benefits derived directly from public recreational facilities were evaluated for this study. On this basis the estimated net annual recreational benefits would be $192,000.

Total estimated benefits from all sources are summarized in Table 51.

The resulting ratio of benefits to costs for the Squaw Queen Project would be 0.85:1 (1959).

TABLE 50

SUMMARY OF ESTIMATED COSTS OF SQUAW QUEEN PROJECT

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$ 7,034,000
Lands, easements, and rights of way	151,000
Relocation of public utilities	90,000
Subtotal	$ 7,275,000
Engineering and administration	$ 728,000
Contingencies	1,091,000
Interest during construction	278,000
TOTAL CAPITAL COST	$ 9,412,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 475,000
Operation and maintenance, replacement, general expense, and insurance	127,000
Taxes foregone	101,000
Subtotal	$ 703,000
Public recreational facilities, including operation and maintenance	$ 58,000
TOTAL ANNUAL COST	$ 761,000

TABLE 51

ESTIMATED AVERAGE ANNUAL NET BENEFITS FROM SQUAW QUEEN PROJECT

Item	Benefits
Hydroelectric power	$452,000
Recreation	192,000
TOTAL	$644,000

Genesee Recreation Project

Genesee Recreation Project would include the construction of Genesee Dam and Reservoir on Indian Creek in Genesee Valley and the development of the valley for intensive recreational use. Genesee Reservoir would be operated as an afterbay for the Squaw Queen Power Project, when and if that project were constructed, and would have a maximum fluctuation of about one foot in order to maximize its recreational potential. The regulated releases from the reservoir would enhance the recreational potential of Indian Creek. Camp sites and other outdoor recreational facilities and resort establishments would be located near the reservoir and along Indian Creek.

It is estimated that the public recreational facilities developed in connection with the project would provide an average of over 1,000,000 visitor-days of use seasonally during the repayment period of the project. Location of the project is shown on Plate 6.

Genesee Dam would be located on Indian Creek about two miles above Genesee in Sections 10 and 11, Township 25 North, Range 11 East, MDB&M. A topographic map of the reservoir area at a scale of one inch equals 400 feet and a contour interval of 10 feet was made in 1957. Reservoir area and capacity data taken from this map are presented in Table 52.

TABLE 52

AREAS AND CAPACITIES OF GENESEE RESERVOIR

Depth of water at dam, in feet	Water surface elevation, in feet	Water surface area, in feet	Storage capacity, in acre-feet
0	3,692	0	0
8	3,700	241	450
18	3,710	475	4,050
28	3,720	675	9,800
38	3,730	875	17,500

The geologic investigation of the Genesee dam site included a brief geologic reconnaissance, drilling of two holes in the channel section to a depth of 35 feet each, and a seismic survey. In addition, potential borrow areas were located and samples were taken for laboratory testing.

The right abutment of the dam site is underlain by deeply weathered, well-indurated, tuffaceous volcanics and sandstone covered with several feet of sandy overburden. The material in the broad channel section consists of stream-deposited, unconsolidated pervious sands, silty sands, and gravels with about five feet of sandy and clayey silty soil at the surface. Water tests conducted during the drilling operations indicated moderate seepage losses. The seismic survey indicated that depth to bedrock in the channel section would range from 50 feet near the right abutment to over 200 feet near the stream channel.

The left abutment of the dam site is composed of deeply weathered, slaty shales with some interbedded sandstone. The rocks weather to a sandy soil which has formed a deep blanket over the abutment. The stripping depth beneath the impervious section of a dam would be about 15 feet. The saddle behind the knoll which forms the right abutment appears to be well suited for the location of a spillway. Based on preliminary geologic exploration, the Genesee dam site appears suitable for the construction of a low earthfill dam.

Geologic conditions at Genesee Dam site are shown on Plate 18, "Genesee Dam on Indian Creek".

From a consideration of topographic and geologic conditions, a reservoir with a storage capacity of 9,800 acre-feet was selected for cost analysis of the Genesee Recreation Project. The reservoir water surface area would be 675 acres at normal pool elevation. The dam would be of earthfill construction with a height of 44 feet and a crest length of 1,700 feet. The embankment slopes would be 3 to 1 upstream and 2 to 1 downstream. The spillway would be located in a saddle near the right abutment of the dam and would have a discharge capacity of 30,000 second-feet. A concrete weir 200 feet in length would control spills into a chute terminating in a stilling basin at stream bed level. The outlet works were designed to discharge 200 second-feet with the reservoir water surface at minimum pool. It would have a submerged inlet structure connecting to a 3-foot diameter welded steel pipe encased in concrete in a trench in the right abutment. Principal features of the Genesee Recreation Project and related data are presented in Table 53.

Most of the land in Genesee Reservoir area is under private ownership and is devoted to grazing. Clearing of the land would consist of the removal of scattered trees and several ranch buildings.

The economic analysis of the Genesee Recreation Project consisted of a preliminary determination of the economic justification of the project. The capital cost of the project was estimated to be about $3,183,000. Corresponding annual costs using an interest rate of 4.0 percent per annum and an amotrization period of 50 years, plus operation, maintenance and replacement, were estimated to be $310,000. An estimate of costs of individual project features is presented in Appendix C. A summary of

Genesee Valley

TABLE 53

GENERAL FEATURES OF GENESEE RECREATION PROJECT

Dam Site	
Location	Sec. 10 & 11, T25N, R11E, MDB&M
Stream	Indian Creek
Dam	
Type	homogeneous, impervious fill
Crest elevation, in feet	3,736
Crest length, in feet	1,700
Crest width, in feet	20
Height above stream bed, in feet	44
Freeboard above spillway crest, in feet	16
Side slopes	
Upstream	3:1
Downstream	2:1
Elevation of stream bed, in feet	3,692
Volume of fill, in cubic yards	314,600
Reservoir	
Water surface at normal pool, in feet	3,720
Surface area at spillway crest, in acres	675
Storage capacity at spillway crest, in acre-feet	9,800
Drainage area, in square miles	518
Type of spillway	Ogee weir with rectangular chute
Spillway discharge capacity, in second-feet	30,000
Type of outlet works	steel pipe encased in concrete

capital and annual costs are presented in Table 54. The benefits that would accrue to the Genesee Recreation Project would result from enhancement of the outdoor recreational potential of Genesee Valley. Only those recreational benefits derived directly from public recreational facilities were evaluated for this study. On this basis, the estimated net annual recreational benefits would be $340,000. The resulting ratio of benefits to costs would be 1.1 to 1 (1959).

Humbug Valley Dam and Reservoir

A reconnaissance study was made of the possibilities for a Humbug Valley Dam and Reservoir on Yellow Creek. The reservoir would be formed by a dam on Yellow Creek about one mile below the mouth of Humbug Valley in Section 18, Township 26 North, Range 7 East, MDB&M. The location of the reservoir is shown on Plate 19, "Existing North Fork and Proposed Yellow Creek and South Fork Developments".

Reconnaissance studies of the reservoir indicate its best use would be realized when operated to augment the water supply available to the existing power plants on the North Fork of the Feather River. The reservoir would provide a firm water yield on a continuous flow basis of about 19,000 acre-feet seasonally.

New recreational opportunities would be made available by the project. It would enhance outdoor recreation by providing a setting for the development of camp sites, boating facilities, and summer homes.

The geologic investigation of the Humbug Valley dam site consisted of a brief reconnaissance of the site and the location and sampling of construction material. Humbug Valley is a narrow, alluviated valley located in an area of moderately subdued topography. The area is in the transition zone between the older metamorphic rocks of the Sierra Nevada and the younger volcanic rocks

TABLE 54

SUMMARY OF ESTIMATED COSTS OF
GENESEE RECREATION PROJECT

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$ 1,752,000
Lands, easements, and rights of way	653,000
Relocation of public utilities	105,000
Subtotal	$ 2,510,000
Engineering and administration	$ 251,000
Contingencies	376,000
Interest during construction	46,000
TOTAL CAPITAL COST	$ 3,183,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 161,000
Operation and mainteancce, replacement, general expense, and insurance	2,000
Subtotal	$ 163,000
Public recreational facilities, including operation and maintenance	$ 147,000
TOTAL ANNUAL COST	$ 310,000

associated with Mt. Lassen and with the Cascade geomorphic province. Slate, schist, meta-volcanics, and quartzite are exposed at the site, and in and around Humbug Valley. Seismicity may be considered to be low to moderate.

Humbug Valley dam site is situated in a steep-walled, narrow canyon at the outlet of the valley. The north-northwest regional structural trend is reflected in the formational contacts and in the jointing and foliation of the rocks. At the axis of the dam site, the joints, foliation, and probable shear zones roughly parallel the channel. The right abutment is underlain by massive, jointed meta-volcanic rocks. Apparent outcrops on the abutment are probably very large, massive boulders formed as a result of weathering. Stripping for the impervious section of a fill dam is estimated to include removal of about eight feet of bouldery soil overburden and two feet of jointed rock. The channel section is about 150 feet wide. About one-fifth of the channel section is occupied by the stream channel. The channel fill is predominantly silt with a little gravel, the estimated depth being 15 feet. This fill would be removed from beneath the impervious section. Stripping should also include removal of about three feet of jointed bedrock. Since prominent joints, foliation, and probable shear zones roughly parallel the channel, grouting should be deep, and grout holes should have narrow spacing to control seepage under the dam. Fractured meta-volcanics are exposed in a few outcrops on the left abutment. Stripping beneath the impervious section should include about four feet of overburden and three feet of rock.

A side-channel spillway could be cut across the right abutment. The spillway should be lined to prevent plucking of the jointed rocks. The natural slope above the spillway appears to be stable. The sides of the spillway cut should be stable on a 1:1 slope in bedrock.

Leakage from the reservoir through the jointed metamorphic rocks should be slight. Gravelly silts located within two miles of the dam site in the reservoir area may be suitable for impervious fill. Pervious rockfill and riprap materials can be quarried at the dam site. The site appears to be geologically suitable for the construction of a zoned earth and rockfill dam with a height of up to 150 feet.

Based on geologic reconnaissance and preliminary economic analysis, an earthfill dam, 104 feet in height with a crest elevation of 4,360 feet was selected for cost analysis of Humbug Valley Dam and Reservoir. A concrete-lined side channel spillway would be located in the right abutment. The outlet works would be located in the left abutment. The reservoir would have a storage capacity of 55,000 acre-feet and an area of 1,630 acres at normal pool elevation. Principal features of Humbug Valley Dam and Reservoir aree presented in Table 55.

The capital cost of Humbug Valley Dam and Reservoir was estimated at $2,189,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, were estimated to be $121,000. A summary of capital and annual costs of Humbug Valley Dam and Reservoir are presented in Table 56.

For the purpose of this study, no analysis was made of the benefits that would be derived from the operation of Humbug Valley Dam and Reservoir, as it would be used only in conjunction with the existing North Fork power system.

South Fork Project for Development of the South Fork of the Feather River

As previously stated herein, a plan for developing the South Fork of the Feather River has been advanced by the Oroville-Wyandotte Irrigation District. This plan has been accepted by the Yuba County Water District as a joint project of the two agencies in accordance with an agreement entered into in 1958 with the Pacific Gas and Electric Company. This agreement provides for the sale to the company of the electric energy developed by the project. Because of the advanced stage of planning by the district for the development of the waters

TABLE 55

GENERAL FEATURES OF HUMBUG VALLEY DAM AND RESERVOIR

Dam Site	
Location	Sec. 18, T26N, R7E, MDB&M
Stream	Yellow Creek
Dam	
Type	zoned earthfill
Crest elevation, in feet	4,360
Crest length, in feet	560
Crest width, in feet	25
Height above stream bed, in feet	104
Freeboard above spillway crest, in feet	10
Side slopes	
Upstream	2.25:1
Downstream	2.25:1
Elevation of stream bed, in feet	4,256
Volume of fill, in cubic yards	427,680
Reservoir	
Water surface elevation at normal pool, in feet	4,350
Surface area at spillway crest, in acres	1,630
Storage capacity at spillway crest, in acre-feet	55,000
Drainage area, in square miles	35
Average seasonal runoff, in acre-feet	27,000
Seasonal yield of water, in acre-feet	19,000
Type of Spillway	concrete-lined, side channel
Spillway discharge capacity, in second-feet	5,700
Type of outlet works	concrete-encased steel pipe

TABLE 56

SUMMARY OF ESTIMATED COSTS OF
HUMBUG VALLEY DAM AND RESERVOIR

(Based on prices prevailing in 1959)

Item	Cost
CAPITAL COST	
Project construction	$ 1,275,000
Lands, easements, and rights of way	277,000
Relocation of public utilities	132,000
Subtotal	$ 1,684,000
Engineering and administration	$ 168,000
Contingencies	252,000
Interest during construction	85,000
TOTAL CAPITAL COST	$ 2,189,000
ANNUAL COST	
Reservoir, conveyance, and power features	
Interest and capital recovery	$ 102,000
Operation and maintenance, replacement, general expense, and insurance	19,000
TOTAL ANNUAL COST	$ 121,000

of the South Fork, no additional planning for the development of this stream was done for the purposes of the Upper Feather River Basin Investigation.

The South Fork Project is a proposed water supply and hydroelectric power project within the South Fork of the Feather River and North Fork of the Yuba River Basins. The principal purpose of the project would be to provide additional irrigation and domestic water supplies for use in the Oroville-Wyandotte Irrigation District, in areas adjacent to the district, and in the Yuba County Water District. Hydroelectric energy would be developed to provide revenue for repayment of the project costs.

The proposed project would consist of three storage reservoirs with a total storage capacity of approximately 156,000 acre-feet, four diversion dams, three power plants with a total generating capacity of 85,000 kilowatts, 17 miles of tunnel, and certain other works, including a small terminal storage reservoir and irrigation canals. The existing Lost Creek Reservoir would be included in the system. The plan of the South Fork Project is shown on Plate 19.

Under the plan of development, Little Grass Valley Reservoir with a storage capacity of 93,010 acre-feet would be constructed on the South Fork of the Feather River. The dam would be of earth and rockfill construction and would have a height of 202 feet. The conserved water from the reservoir would be released to the stream for diversion to Lost Creek by the South Fork diversion works. The diversion works would consist of a concrete arch dam with a height of 57 feet. From the diversion works, the conserved water would be conveyed 2.6 miles by tunnel for storage in Sly Creek Reservoir. From Sly Creek Reservoir, the conserved water would be released to existing Lost Creek Reservoir immediately downstream. Slate Creek diversion dam, a concrete arch structure 70 feet in height, would be located on Slate Creek. Water from Slate Creek would be diverted 2.4 miles by tunnel for storage in Sly Creek

Reservoir. From Lost Creek Reservoir the conserved water would be conveyed 3.5 miles by tunnel to pass through Woodleaf Power Plant located on the South Fork. The Woodleaf Power Plant would have an installed capacity of 49,900 kilowatts. The Forbestown diversion dam would be located downstream from the power plant and would be concrete arch construction with a height of 73 feet. From this reservoir the conserved water would be conveyed 3.51 miles by tunnel to pass through the Forbestown Power Plant. This plant would have an installed power capacity of 27,600 kilowatts. After passing through the power plant, the conserved waters would be diverted into the Miners Ranch conduit by the Ponderosa diversion dam. This dam would have a height of 163 feet. The Miners Ranch conduit would consist of 3.69 miles of tunnel and 6.55 miles of sidehill canal. The conduit would discharge into Miners Ranch terminal reservoir with an active storage capacity of 912 acre-feet. This reservoir would be operated to regulate releases to the Kelly Ridge Power Plant located on the Feather River and to make releases for irrigation use. The conduit to the Kelley Ridge Power Plant would include 0.35 mile of canal and 0.92 mile of tunnel. The power plant would have an installed power capacity of 9,000 kilowatts.

Irrigation facilities that would be constructed as part of the South Fork Project are described in an agreement between Oroville-Wyandotte Irrigation District and Yuba County Water District. These facilities would consist of 2.2 miles of conduit extending from Miners Ranch terminal reservoir to the outlet of Mt. Ida Siphon, and Bangor Canal which would extend approximately 14 miles southward from the terminal reservoir. In addition, the Yuba County Water District would extend its canal from Dry Creek to the Dobbins and Oregon House areas.

CHAPTER VII. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The rapid expansion of population in California since World War II, and the corresponding increase in water requirements, have resulted in a need for an accelerated program of water resource development. The Legislature, realizing the urgency of this need, has provided funds for planning a coordinated statewide development of water resources. With the initiation of action to develop the Feather River and Delta Diversion Projects as initial units of the California Water Development System, the people of the northern part of the State became concerned over the disposition of local water supplies. Consequently, the Legislature provided funds for the Upper Feather River Basin Investigation.

This investigation has as its basic objective the completion of engineering, geologic, and economic studies directed toward the development of a basin-wide master plan for multi-purpose water development for all beneficial uses. The beneficial uses of water considered include irrigation, domestic, recreation, and fish and wildlife, and production of hydroelectric power.

Summary

The Upper Feather River Basin is located in Northeastern California and consists of the portion of the basin located upstream from the authorized Oroville Dam located on the Feather River near Oroville. It contains an area of about 2,261,000 acres, most of which are in the Plumas National Forest. The Feather River, the largest tributary of the Sacramento River system, has an average seasonal natural flow at Oroville of about 4,244,000 acre-feet.

There is considerable variation in geologic structure and topography throughout the upper basin. The Cascade Range, consisting of volcanic ridges and mountains, extends from the north into the basin to contact with the Sierra Nevada, which loosely could be termed a huge granitic monoclinal fault block. The elevation of the basin ranges from 10,457 feet on Mt. Lassen, the principal feature of the southern Cascade Range; to over 8,000 feet for numerous peaks of the northern Sierra Nevada; to 5,000 to 6,500 feet for the high open mountain valleys and plateaus located in the eastern part of the basin; to less than 300 feet at Oroville.

The upper basin is a region of significant climatic differences. There are substantial changes in temperature and precipitation within short distances where air movement is modified by the topography. In the eastern portion of the upper basin, the winters are moderately severe with monthly minimum temperatures remaining below freezing during the period from November through March. The summers are warm with cool nights. In the lower, or southwestern, part of the basin the winters are mild, and the summers are hot and dry.

In most parts of the upper basin, there are sufficient surplus flows, if properly controlled and developed, to more than meet present and future local water requirements. However, this is not true in Sierra Valley, since there is insufficient water available to meet water requirements for full development of all irrigable lands. In this area, it is probable that future development will be limited by the amount of water that can be economically developed.

The ultimate water requirements of the entire upper basin would cause a reduction in the present flow of the Feather River at Oroville of about 10 percent. The present summer flows of the Feather River that remain after satisfying upper basin requirements are diverted for irrigation use in the Sacramento Valley. The winter flows are wasted to the ocean.

The economy of the upper basin is based principally on lumbering, raising of livestock, and recreation. Also of importance to the upper basin is the hydroelectric power industry since it provides a considerable portion of the property tax base. Present indications are that these activities will continue to be the dominant features of the economy of the area.

The present permanent population of the upper basin is about 12,500 scattered over 3,520 square miles, an average of less than three people to the square mile. It is expected, however, that a considerable increase in population will occur in the future.

Water Rights

On the Feather River above Oroville, rights have been established by a few entities to divert and store water for purposes of irrigation and production of hydroelectric power.

In the Upper Feather River Basin, the water rights have been adjudicated in the stream systems of Sierra Valley and Indian Creek. On the Feather River below Oroville, rights have been established by several entities to divert water for irrigation use in the Sacramento Valley. Also, state applications have been filed for the appropriation of water at Oroville Reservoir and five Upper Feather River Basin reservoir sites.

South Fork of the Feather River. On the South Fork of the Feather River, permits have been issued jointly to the Oroville-Wyandotte Irrigation District and the Yuba County Water District for a South Fork Project. This project is in the final planning stage and will be constructed as soon as financing of the project can be arranged.

North Fork of the Feather River. On the North Fork of the Feather River, water rights have been obtained for extensive hydroelectric power development by the Pacific Gas and Electric Company.

Middle Fork of the Feather River. Applications Nos. 13681, 13682, 14919, 14920, 15551, and 15552 were filed by the Richvale Irrigation District in support of its proposed project on the Middle Fork of the Feather River. The applications were advertised by the State Water Rights Board and the first day of hearing was held in October 1959. The matter is now (October 1960) awaiting a further hearing before the board.

On September 22, 1959, Richvale Irrigation District requested the California Water Commission to release from priority State Applications Nos. 5629, 5630, 14443, 14444, and 14445 in favor of the applications of the district. The commission has held hearings on the requests of the Richvale Irrigation District and has the matter under consideration (October 1960).

State Applications Nos. 5629, 5630, 14443, 14444, and 14445 have also been filed for water from the Feather River for the Feather River and Delta Diversion Projects. These applications propose the appropriation of water from the Feather River and channels of the Sacramento-San Joaquin Delta. The Department of Water Resources has requested the California Water Commission to assign to it Applications Nos. 5629, 5630, 14443, 14444 and a portion of Application No. 14445. The commission has held hearings on the requests of the department and also has these requests under consideration (October 1960).

A material difference in viewpoint exists between the State and Richvale Irrigation District in regard to the proposed use of water to be made available by Grizzly Valley Reservoir. Under the state plans water from Grizzly Valley Reservoir would be used primarily for irrigation in Sierra Valley when and as needed. Under the Richvale Plan, that water would be denied to Sierra

Valley for at least 20 years and instead would be used for generation of hydro-electric energy and irrigation of land in various districts within Sutter and Butte Counties.

In assigning or releasing the priority of any state applications, the California Water Commission must give consideration to Section 10505 of the Water Code commonly known as the "County of Origin" law. This section provides that no assignment or release of priority shall be made which, in the judgment of the commission, will deprive the county in which the water originates of any water necessary for its development.

Water Supply

The water supply of the Upper Feather River Basin largely occurs as precipitation. Melting snow produces the major portion of the seasonal runoff and occurs in the late spring and early summer months. Direct diversion of unregulated stream flow is the principal source of water for irrigation and domestic use. Ground water exists in the alluvial basins, and in many localities, limited water supplies are obtained from individual wells for domestic, stock-watering, and irrigation purposes.

Precipitation on the upper basin varies between wide limits from month to month, from season to season, and generally increases with elevation. Due to the orographic effect of the Sierra Nevada, however, the eastern half of the upper basin, although higher in elevation, receives less precipitation than the western half. Winter storms deposit relatively light precipitation in crossing the floor of the Sacramento Valley, but these storms drop moisture at increasing rates as they are lifted in passing over the Sierra Nevada. A maximum rate of precipitation is reached along the intermittently defined first crest of the Sierra Nevada. Precipitation then decreases rapidly until the effects of local ridges such as Smith Peak, Dixie Mountain, and Kettle Peak reverse the trend. The average seasonal rate of precipitation ranges from a high of about 80 inches along the ridge southwest of Bucks Lake to a low of less than 10 inches in Sierra Valley. Over 75 percent of the average seasonal precipitation occurs during the five months from November 1 to March 31. The seasonal variation in precipitation can be shown by a comparison of the estimated seasonal full natural flows of the Feather River at Oroville. These estimates range from a maximum of about 8,604,000 acre-feet in 1937-38, to a minimum of about 1,307,000 acre-feet in 1923-24.

The principal tributary streams of the Feather River are the North, Middle, and South Forks. The average seasonal natural flow of each stream is: North Fork at Big Bar; 2,199,000 acre-feet; Middle Fork at Bidwell Bar, 1,422,000 acre-feet; South Fork at Enterprise, 256,000 acre-feet. The maximum recorded instantaneous discharge of the Feather River at Oroville occurred during the floods of 1907 when the flow was 230,000 second-feet.

Ground water basins with adequate storage capacity and sufficient permeability to justify development for irrigation exist in Sierra, Indian, and American Valleys. In Sierra Valley, the ground water is confined under extensive, thick, lake sediments, and water flows from many deep wells under artesian pressure. Well logs indicate that the deep aquifers are thin and that ground water production from them would be limited. However, the present rate of extraction could be increased. In American and Indian Valleys, sufficient ground water capacity exists to take care of most future water needs. However, particularly in Indian Valley, there is relatively low permeability of the sediments and consequently very low specific yields.

The surface waters available for storage in reservoir sites in the upper basin are of excellent mineral quality suitable for most beneficial uses. Increased agricultural activity in Sierra Valley in the future will result in greater quantities of irrigation return flow to the Middle Fork Feather River.

Although the quality of water to be impounded in downstream reservoirs may be degraded by increased return flow from Sierra Valley, it should be suitable for most beneficial uses. There are highly mineralized springs in the valley fill areas of the upper basin, particularly in Sierra Valley. However, the quantity of flow is insignificant and these springs cause only localized and minor quality impairment of the major water supplies.

Water Utilization and Requirements

Extensive studies of land use and water requirements within the Upper Feather River Basin were made as part of the Northeastern Counties Investigation. The results of these studies have been published in Bulletin No. 58, "Northeastern Counties Investigation". Data from Bulletin No. 58 were used in the Upper Feather River Basin Investigation.

The gross irrigable area within the upper basin is about 196,000 acres. Irrigable valley lands comprise 133,000 acres and irrigable hill lands comprise 63,000 acres. In addition, there are 147,000 acres of land classified as irrigable, but best suited to forest management. For this latter classification, no future crop pattern or additional water requirement is contemplated.

Under present development, pasture is the principal irrigated crop. Of the 76,000 acres irrigated, 20,000 acres are in improved pasture and 52,000 acres are in meadow pasture. The remaining acreage is devoted primarily to alfalfa and grain hay.

Under ultimate development, it is estimated that 158,000 acres would be irrigated if adequate water supplies were developed. The major items in the ultimate crop pattern were estimated to be improved pasture, 72,000 acres; meadow pasture, 41,000 acres; alfalfa, 18,000 acres; and grain, 12,000 acres; truck crops, 12,000 acres; and orchards, 3,000 acres. In addition, it was estimated that the probable ultimate pattern of urban, suburban, and recreational land use would be as follows: urban and suburban areas, 15,200 acres; high intensity recreational areas, 1,610,700 acres; medium intensity recreational areas, 192,300 acres; low intensity recreational areas, 66,300 acres; and principal reservoirs, 70,800 acres.

The present estimated average mean seasonal consumptive use of applied water on irrigated lands in the upper basin is about 71,000 acre-feet. In addition, the estimated mean seasonal consumptive use of water for domestic purposes is about 1,000 acre-feet. Estimated net reservoir evaporation is about 69,000 acre-feet seasonally.

Estimates of probable ultimate mean seasonal consumptive use of applied water in the upper basin are presented in Table 57.

TABLE 57

PROBABLE ULTIMATE MEAN SEASONAL CONSUMPTIVE USE OF APPLIED WATER WITHIN THE UPPER FEATHER RIVER BASIN
(In acre-feet)

Use	Amount
Irrigation	283,000
Domestic	14,000
Forest products industries	1,000
Recreational areas	14,000
Net reservoir evaporation	204,000
TOTAL	516,000

Estimates of probable ultimate mean seasonal water requirements to meet consumptive demands in the upper basin are presented in Table 58.

TABLE 58

PROBABLE ULTIMATE MEAN SEASONAL WATER REQUIREMENTS
WITHIN THE UPPER FEATHER RIVER BASIN
(In acre-feet)

Use	Amount
Irrigation	391,000
Domestic	29,000
Forest products industries	1,000
Recreational areas	14,000
Net reservoir evaporation	204,000
TOTAL	639,000

Plans for Water Development

The growth and enhancement of the economy of the Upper Feather River Basin is dependent upon the further development of water resources of the basin to provide for local needs. In the valley areas of the basin, the division of the unregulated water supplies available to satisfy current demands has been accomplished by water right adjudication and watermaster service. In these areas, however, the summer and fall water supplies are insufficient to satisfy present and future needs.

Individual plans presented herein for developing the waters of the upper basin were conceived as a part of a basin-wide master plan. Under this master plan water would be developed for all beneficial purposes to return maximum net benefits. Consideration was given first to developments that would provide for the water needs of the upper basin. Second, consideration was given to projects that would develop hydroelectric power for areas elsewhere in the State.

Plans for Development of the Upper Basin

Six projects were planned for the purpose of meeting the water needs of the Upper basin. These projects are the Frenchman Project on Little Last Chance Creek, Grizzly Valley Project on Big Grizzly Creek, Indian Creek Recreation Project in the Indian Creek Basin, Sheep Camp Project on Carman Creek, Squaw Queen Project on Last Chance Creek, and Genesee Recreation Project on Indian Creek. The first three of these projects were reported on in Bulletin No. 59, "Investigation of Upper Feather River Basin Development", February 1957, and were subsequently authorized as part of the Feather River and Delta Diversion Projects. The three authorized projects are described herein but were not studied further in the investigations for this bulletin.

Frenchman Project on Little Last Chance Creek. Construction of the Frenchman Project was initiated in the fall of 1959, and it is expected that the reservoir will be available for water storage in the 1961-62 water year. The project will consist of a dam and reservoir with a storage capacity of 50,000 acre-feet, and a system of works that will regulate the water of Little Last Chance Creek. The project will provide water for irrigation use, partial flood control to downstream lands, and provide the basis for the enhancement of recreational opportunities. The project will provide a regulated water supply of about 16,000 acre-feet seasonally, of which 12,000 acre-feet will be new water that is presently unavailable to irrigators in Sierra Valley. In addition, the presently available unregulated water can be more effectively used during the irrigation season.

The operation of the project will provide incidental flood control. Although no specific reservation of storage space will be made for flood control purposes, storage space above the ungated spillway crest will provide flood protection by reducing the peak flows entering the reservoir. It was estimated that the once-in-100-year flood peak will be reduced from 4,400 second-feet to about 1,300 second-feet, a flow that will cause only negligible damage.

The reservoir will increase the recreational potential of the surrounding area by providing a setting for the building of camp sites, boating facilities, and summer homes. Both the area adjacent to the reservoir site and the canyon downstream are attractive for this type of development.

<u>Grizzly Valley Project on Big Grizzly Creek</u>. The authorized Grizzly Valley Project would consist of a dam and reservoir with a storage capacity of 80,000 acre-feet and a system of works that would regulate the waters of Big Grizzly Creek. The project would provide water for irrigation use, and provide the basis for the enhancement of recreational opportunities. The project would provide a regulated water supply of about 15,000 acre-feet seasonally.

The proposed reservoir would increase recreational opportunities by providing a setting for the building of camp sites, boating facilities, and summer homes. Both the area surrounding the reservoir and the area downstream are desirable for this type of development. Incidental flood protection afforded by the reservoir would have little value since only minor flood damage occurs to downstream property under present conditions.

The service area for the Grizzly Valley Project lies partly within the boundaries of the existing Last Chance Creek Water District and partly in the valley area immediately north and west of the district. Operation of the project would be integrated with the operation of the Frenchman Project. Approximately 6,200 acres, in addition to those served by the Frenchman Project, would receive a full irrigation supply.

Indian Creek Recreation Project. The authorized Indian Creek Recreation Project which also was reported in Bulletin 59, February 1957, would comprise a system of works for regulating the waters of Indian Creek and its tributaries for the enhancement of recreation in Indian Creek Basin. The works would include Antelope Valley Dam and Reservoir on Indian Creek, with a storage capacity of 21,600 acre-feet and a water surface area of 930 acres; Dixie Refuge Dam and Reservoir on Last Chance Creek, with a storage capacity of 16,100 acre-feet and a water surface area of 800 acres; and Abbey Bridge Dam and Reservoir on Red Clover Creek, with a storage capacity of 11,100 acre-feet and a water surface area of 540 acres. It was estimated that an average annual total of 93,200 visitor-days of recreational use, over and above present use, would be realized from developments around the reservoirs. In addition, about 309,000 visitor-days of recreational use annually would be realized from 62 miles of improved streams.

Sheep Camp Project on Carman Creek. The proposed Sheep Camp Project would include the construction of Sheep Camp Dam and Reservoir on Carman Creek, with a storage capacity of 65,000 acre-feet, and an intercepting canal extending northwesterly across Sierra Valley to a pumping plant located at the base of Sheep Camp Dam. The waters intercepted from nine small watersheds that drain onto the valley floor by the intercepting canal would be conveyed to the pumping plant and pumped into Sheep Camp Reservoir. The conserved waters would later be released as required to the intercepting canal for gravity conveyance for the irrigation of lands located below the canal.

The Sheep Camp Project would provide a regulated water supply of about 48,000 acre-feet seasonally, of which 25,000 acre-feet would be new water that presently is unavailable to irrigators in the valley. In addition, the presently available unregulated water supply, could be more efficiently used over the irrigation season. Also, the reservoir would increase recreational opportunities by providing a setting for the building of camp sites, boating facilities, and summer homes.

The capital cost of the Sheep Camp Project was estimated to be about \$5,806,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, were estimated to be about \$415,000. The total average annual benefits from the Sheep Camp Project were estimated to be about \$330,500. Of this amount, \$208,500 would be irrigation benefits, and \$122,000 would be benefits from public recreation facilities.

The resulting ratio of benefits to costs for the Sheep Camp Project would be about 0.8 to 1 (1959).

Squaw Queen Project on Last Chance Creek. The proposed Squaw Queen Project would include the construction of Squaw Queen Dam and Reservoir on Last Chance Creek, with a storage capacity of 100,000 acre-feet, and the conveyance of the conserved waters from the project to a power plant located in Genesee Valley upstream from the junction of Last Chance and Red Clover Creeks. Waters released through the power plant would be reregulated in the proposed Genesee Reservoir, the principal feature of the Genesee Recreation Project.

Under the plan of operation, the releases for stream flow maintenance purposes from the upstream authorized Dixie Refuge Reservoir would pass through Squaw Queen Reservoir to the stream channel below the dam. The Squaw Queen Project would have an installed power capacity of 12,000 kilowatts, a dependable power capacity of 11,300 kilowatts, and would produce 56,570,000 kilowatt-hours of energy seasonally. In addition, the regulated waters from the project would increase the production of hydroelectric energy from the existing Rock Creek, Cresta, and Poe Power Plants of the Pacific Gas and Electric Company by

12,500,000 kilowatt-hours seasonally. Also, the reservoir would increase recreational opportunities by providing a setting for the building of camp sites, boating facilities, and summer homes.

The capital cost of the Squaw Queen Project was estimated to be about $9,412,000. Corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, were estimated to be $761,000. Of this amount, the estimated value of taxes foregone is $101,000.

Total average annual benefits from the Squaw Queen Project were estimated to be about $644,000. Of this amount, $452,000 would be hydroelectric power benefits and $192,000 would be benefits from public recreational facilities.

The resulting ratio of benefits to costs for the Squaw Queen Project would be 0.85 to 1 (1959).

Genesee Recreation Project. The proposed Genesee Recreation Project would include the construction of Genesee Dam and Reservoir on Indian Creek in Genesee Valley, with a storage capacity of 9,800 acre-feet, and the development of the valley for intensive recreational use. Genesee Reservoir would be operated as an afterbay for the Squaw Queen Project when constructed, and would have a maximum fluctuation of about one foot in the reservoir in order to maximize its recreational potential. The regulated releases from the reservoir would enhance the recreational potential of Indian Creek. Camp sites and other outdoor recreational facilities would be located near the reservoir and along Indian Creek.

It is estimated that the public recreational facilities connected with the project would provide an average of over 1,000,000 visitor-days of use seasonally during the repayment period of the project.

The capital cost of the Genesee Recreation Project was estimated to be about $3,183,000. Corresponding annual costs, using an interest rate of 4.0

percent per annum and an amortization period of 50 years, were estimated to be $310,000. Average annual benefits from the Genesee Recreation Project would be $340,000. The resulting ratio of benefits to costs would be 1.1 to 1 (1959).

Plans for Hydroelectric Power Development

Alternative plans were considered for developing the waters of the Middle Fork of the Feather River for the production of hydroelectric power and to provide water for areas in the Sacramento Valley. In addition, Humbug Valley Dam and Reservoir on Yellow Creek was studied for the purpose of increasing the production of hydroelectric energy in the existing power plants located on the North Fork of the Feather River. Also, the Oroville-Wyandotte Irrigation District, in cooperation with the Yuba County Water District, is proceeding with plans for the development of the waters of the South Fork of the Feather River.

Alternative Middle Fork Projects. Studies were made of six alternative plans for developing the waters of the Middle Fork of the Feather River. These alternatives are the Richvale, Modified Richvale, Clio-Nelson Point-Swayne, Nelson Point-Meadow Valley-North Fork, Nelson Point-Meadow Valley-Bald Rock, and the Turntable-Meadow Valley-Swayne Plans. The projects proposed under these plans would be operated primarily to produce hydroelectric energy. However, they would also produce new water for use in areas outside the upper basin and would increase the recreational potential of the basin.

The studies of the alternative projects were directed toward a comparison of their accomplishments and were limited to a preliminary determination of engineering feasibility and economic justification. The reservoir operation studies were conducted under the assumption that the present water supply of the Middle Fork would be depleted by the upstream Frenchman, Grizzly Valley, and Sheep Camp Projects and by additional ground water development. It was estimated that this depletion would amount to an average of about 66,000 acre-feet seasonally during the repayment period of a Middle Fork Project. Also, it was assumed that for stream flow maintenance purposes there would be a minimum release of 20 second-feet from Clio Reservoir, 10 second-feet from Meadow Valley Reservoir, and 75 second-feet from all reservoirs located downstream from Sloat. These stream flow amounts are subject to review by the Department of Fish and Game.

The accomplishments, the estimated capital and annual costs, and the benefit of cost ratios of the alternative possibilities for developing the waters of the Middle Fork Basin are summarized in Table 59.

Humbug Valley Dam and Reservoir on Yellow Creek, North Fork of the Feather River. Reconnaissance studies were made of the proposed Humbug Valley Dam and Reservoir on Yellow Creek. This reservoir would have a storage capacity of 55,000 acre-feet. These studies indicate that the best use of the reservoir would be realized when operated to augment the water supply available to the existing power plants on the North Fork of the Feather River. For this purpose, the reservoir would provide a firm water yield on a continuous flow basis of about 19,000 acre-feet seasonally. Also, new recreational opportunities would be made available by the project. It would enhance outdoor recreation by providing a setting for the development of camp sites, boating facilities, and summer homes.

The capital cost of Humbug Valley Dam and Reservoir was estimated to be about $2,189,000. The corresponding annual costs, using an interest rate of 4.0 percent per annum and an amortization period of 50 years, were estimated to be $121,000. For the purposes of this reconnaissance analysis, no estimate was made of the benefits that would be derived from the operation of Humbug Valley Dam and Reservoir, as it would be used only in conjunction with the existing North Fork power system.

TABLE 59

SUMMARY OF ESTIMATED ACCOMPLISHMENTS AND COSTS
OF ALTERNATIVE PLANS FOR DEVELOPING THE MIDDLE FORK OF THE FEATHER RIVER

Project	Seasonal new water yield, in acre-feet*	Power plants		Average annual benefits, in 1,000 dollars				Capital costs, in 1,000 dollars	Average annual cost, in 1,000 dollars**	Benefit-cost ratio (1959)
		Dependable capacity, in kilowatts	Installed capacity, in kilowatts	Project power plants (net)	Recreational	Irrigation	Total			
Richvale				Not evaluated						
Modified Richvale	45,000	123,900	150,000	5,025	282	360	5,667	117,853	8,210	0.69
Clio-Nelson Point-Swayne	137,000	174,800	195,500	6,512	355	1,096	7,963	156,074	10,618	0.75
Nelson Point-Meadow Valley-North Fork	133,000	118,500	118,500	5,099	444	1,064	6,607	143,374	8,926	0.74
Nelson Point-Meadow Valley-Bald Rock	168,000	209,000	220,000	7,735	423	1,344	9,502	190,989	12,614	0.75
Turntable-Meadow Valley-Swayne	191,000	273,000	273,000	9,612	492	1,528	11,632	233,483	15,238	0.76

*Seasonal yield on a firm irrigation demand schedule.
**Includes annual value of taxes foregone.

South Fork of the Feather River Plan of Oroville-Wyandotte and Yuba County Districts. A plan for developing the South Fork of the Feather River has been advanced by the Oroville-Wyandotte Irrigation District. This plan has been accepted by the Yuba County Water District as a joint project of the two agencies in accordance with an agreement entered into in 1958 with the Pacific Gas and Electric Company. This agreement provides for the sale to the company of the electric energy developed by the project. Because of the advanced stage of planning for the development of the waters of the South Fork, no additional planning for the development of this stream was done for the purposes of the Upper Feather River Basin Investigation.

The South Fork Project is a proposed water supply and hydroelectric power project within the South Fork of the Feather River and North Fork of the Yuba River Basins. The principal purpose of the project would be to provide additional irrigation and domestic water supplies for use in the Oroville-Wyandotte Irrigation District, in areas adjacent to the district, and in the Yuba County Water District. Hydroelectric power would be developed to provide revenue for repayment of the project costs.

Conclusions

As a result of the field surveys and from analyses of the data developed for the Upper Feather River Basin Investigation, the following conclusions have been reached.

1. The present economy of the upper basin is based principally on lumbering, raising of livestock, and recreation. Also of importance is the hydroelectric power industry. Because water is an essential part of all these activities, the growth and enhancement of the economy of the upper basin will depend to a considerable extent upon further development of the available water resources.

2. The mean seasonal natural flow of the Feather River at Oroville is estimated to be 4,244,000 acre-feet. Of this amount, the North Fork Basin contributes about 2,199,000 acre-feet, the Middle Fork Basin about 1,166,000 acre-feet, the South Fork Basin about 256,000 acre-feet, and the remaining portion of the basin about 623,000 acre-feet.

3. In most parts of the upper basin, there are surplus flows that, if properly controlled and regulated, could more than meet total ultimate water requirements. This is not true in Sierra Valley, however, where it is indicated that there are insufficient water resources available to meet water requirements for full development of all irrigable land.

4. The surface waters of the upper basin available are of excellent quality suitable for most beneficial uses.

5. Even after the probable ultimate water requirements of the upper basin have been met, except as noted above in Sierra Valley, large surplus flows will be available for export to water-deficient areas in other parts of the State.

6. The gross irrigable area within the upper basin is about 196,000 acres. Of this amount, irrigable valley lands comprise 133,000 acres and irrigable hill lands comprise 63,000 acres. In addition, there are 147,000 acres of irrigable land classified as best suited to forest management.

7. Under present development, about 76,000 acres in the upper basin receive a partial irrigation supply. Of this total, 20,000 acres are in improved pasture and 52,000 acres are in meadow pasture. The remaining irrigated acreage is devoted to alfalfa and grain hay.

8. The present mean seasonal consumptive use of applied water on irrigated lands in the upper basin is about 71,000 acre-feet. In addition, estimated mean seasonal consumptive use of water for domestic purposes is about

1,000 acre-feet, and the estimated net reservoir evaporation is about 69,000 acre-feet.

9. Under conditions of ultimate development in the upper basin, it is estimated that a net land area of 158,000 acres could be irrigated if adequate water supplies are developed. The major items in the estimated ultimate crop pattern would be improved pasture, 72,000 acres; meadow pasture, 41,000 acres; alfalfa, 18,000 acres; grain, 12,000 acres; truck crops, 12,000 acres; and orchard, 3,000 acres.

10. The estimate of ultimate mean seasonal consumptive use of applied water for all purposes is about 516,000 acre-feet. Of this amount, 283,000 acre-feet would be utilized on irrigated lands, 14,500 acre-feet by urban and suburban lands, 1,200 acre-feet for the forest products industry, and 13,600 acre-feet on recreational lands. Also included in the total would be 205,000 acre-feet of water consumed by evaporation.

11. The Sheep Camp Project on Carman Creek and the Squaw Queen Project on Last Chance Creek are not economically justified at this time.

12. The Genesee Recreation Project on Indian Creek is engineering feasible and economically justified. However, the estimated benefit-cost ratio is only 1.1 to 1.0, and economic justification is marginal.

13. Under the assumptions used by the department in analyzing five alternative plans for developing the waters of the Middle Fork of the Feather River, none of the alternatives is economically justified at this time.

Recommendations

To aid in the implementation of a basin-wide master plan for multipurpose water development for all beneficial uses it is recommended that:

1. In assigning or releasing from priority Applications Nos. 5629, 5630, 14443, 14444, and 14445, filed in furtherance of the Feather River and Delta Diversion Projects, a general reservation be made by the California Water Commission for use of such water as may be necessary for the development of the counties in which the water originates.

2. The plans for water resource development of the Upper Feather River Basin presented in this bulletin serve as a general guide to future development of the water resources of the basin, that the California Water Plan be modified accordingly, and further, that the plans be reviewed and re-evaluated at that time in the future when economic and other conditions may so dictate.

3. In addition to taking all feasible measures, including adequate stream flow maintenance, for the preservation of the existing fish and wildlife resources, in future water development projects provision should be made for the enhancement of such fish and wildlife resources and for the development of the recreational potential of the area to the maximum feasible extent.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

BULLETIN NO. 59-2

INVESTIGATION OF UPPER FEATHER RIVER BASIN DEVELOPMENT

APPENDIX A

RECREATIONAL BENEFITS FROM UPPER FEATHER RIVER BASIN DEVELOPMENT

EDMUND G. BROWN
Governor

HARVEY O. BANKS
Director of Water Resources

July, 1959

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
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STATE OF CALIFORNIA
Department of Water Resources
SACRAMENTO

INTRODUCTORY STATEMENT

The Upper Feather River Basin Investigation was conducted under legislative authorization by the State of California, Department of Water Resources. The objective of the investigation was to develop a basin-wide master plan for multipurpose water development for all beneficial uses.

As part of the economic studies conducted for the purposes of the investigation, a study was made of the recreational potential and benefits attributable to the features of the basin-wide plan. The recreational benefits would result from activities at the reservoir sites and from stream flow maintenance for the enhancement of fish and wildlife.

The firm of Pacific Planning and Research, consultants in planning and urban economics, was retained by the Department to conduct the recreational studies and analyses. This is their report. It sets forth data and conclusions relating to the recreational aspects of the features of the basin-wide plan. These data are the basis for the estimates of costs and benefits of the public recreational facilities presented in Bulletin No. 59-2 of the Department of Water Resources, entitled "Investigation of the Upper Feather River Basin Development".

RECREATION BENEFITS
FROM THE UPPER FEATHER RIVER BASIN DEVELOPMENT

Report Prepared by
Pacific Planning and Research
Consultants in Planning,
Natural Resource Development,
and Economics

for the

State of California
Department of Water Resources

June 1959

Pacific Planning and Research, Inc.
707 Forum Building
Sacramento 14, California

GILBERT 2-4877

ACIFIC PLANNING AND RESEARCH

AND REGIONAL PLANNING • URBAN RENEWAL • GOVERNMENT STUDIES • RESOURCE PLANNING

707 FORUM BUILDING
SACRAMENTO, CALIFORNIA

Mr. Harvey O. Banks, Director
California State Department of Water Resources
Sacramento 14, California

July 1, 1959

Dear Mr. Banks:

This report on recreation benefits from the Upper Feather River Basin development completes the work we began in 1956 under contract with your Department.

The analysis of recreation benefits from Upper Feather River Basin development must be placed in the context of anticipated population growth and resulting outdoor recreation requirements as related to the recreation development potential of the Upper Feather River Basin. Irrespective of recreation development stemming from water projects in the area, the Upper Basin will contribute appreciably to meeting the requirements of outdoor recreation. The purpose of these physical and economic evaluations was to determine the economic feasibility of public recreational developments in conjunction with possible water development programs in the Basin.

Public outdoor demand during the fifty-year payout period (1961 to 2010) of the proposed projects will assure that use will keep pace with public development programs projected for the fourteen recreation areas evaluated in this study. The analysis presented in this report indicates that if the reservoirs are built recreation use will, by itself, yield benefits which will substantially outweigh the costs of the public facilities needed to make such use possible. Planned and protected public and private recreational development in the Upper Basin will permit greater use without destroying the area's natural beauty or its timber and water-producing capability.

Some of the pioneering work in the development of the concepts, principles and standards utilized in this report and in the measurement of recreation benefits would have been impossible without the full cooperation and sympathetic understanding of your staff. We further appreciate the efforts of the Division of Water Resources Planning in furnishing us engineering, operational and development data on the reservoir areas as rapidly as these were available.

It is our belief that this study of recreation use and benefit in a full drainage basin of some 3,360 square miles will be useful not only to the area itself but to the state in further analyses of natural resource areas and to other states struggling in their effort to keep pace with the rapidly increasing recreation demand.

Sincerely yours,

Samuel E Wood

SAMUEL E. WOOD
Director

OTHER OFFICES: 546 UNIVERSITY AVENUE, PALO ALTO, CALIFORNIA • 125 W. THIRD ST., TULSA, OKLAHOMA

GENERAL CONTRACT PROVISIONS

In 1956, the consultants contracted with the Department of Water Resources to prepare a study on possible recreation benefits resulting from water development in the Upper Feather River Basin. The contract called for the determination of present recreation use in the study area and the projection of this use without water development to the year 2050. Additional recreation use was to be determined if new reservoir recreation areas were developed and folded into the sum of recreation use without water development. The contract further provided for the preparation of general site plans for each recreation area, the costing of the public facility features of these plans for the payout period of the projects, the development and application of a dollar value for each visitor day as an indication of direct benefit, and the preparation of benefit cost studies on the public recreation facilities for each reservoir recreation area and total benefits and costs for the full development. The entire investigation was to equal the feasibility standards of the state's own studies on the same reservoirs.

A preliminary report of the investigations on the basin and five reservoirs was published as Appendix A of Bulletin 59 in January 1957. In May 1957 the studies thus inaugurated were substantially enlarged to conform with the most recent investigations of the Department of Water Resources and to provide for comparisons of alternate schemes of development on the Middle Fork of the Feather River. The character of the studies was again changed in September 1957 when more detailed investigations resulted in dropping two projects of doubtful engineering feasibility and including two additional reservoirs. The details substantiating the summary report submitted on five reservoir areas in 1957 are contained in this full study. These reservoirs (now authorized for construction) are Grizzly Valley, Antelope Valley, Abbey Bridge, Dixie Refuge and Frenchman. The nine additional recreation areas connected with water projects under study and covered in this report are Squaw Queen, Sheep Camp, Turntable, Meadow Valley, Genessee Valley Park, Swayne, Humbug, Nelson Point and Clio.

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ACKNOWLEDGEMENT

Special recognition must go to those representing the commercial recreation interests in the Basin -- the owners and operators of motels, hotels, resorts and other recreational facilities who assisted in the inventory of existing resources. The following representatives of official agencies and private individuals, both within the Upper Feather River Basin and those interested in the development of the area, have assisted the consultants in the collection of data necessary for this report. The evaluations and the conclusions, of course, are the responsibility of the Pacific Planning and Research.

Aid in the delineation of areas, field reconnaissance, use of maps and equipment, and review of recreation area uses:

Supervisor William A. Peterson and his staff of Plumas National Forest, particularly, Messrs. Fisher, Peckinpah, Asplund, Crane, Barrett, Schubert and DeSoso

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L. A. Rickel, Supervisor, Tahoe National Forest

Plumas County officials and citizens who extended valuable assistance in the survey and projections:

Board of Supervisors (1956-57):

A. C. Donnenwirth, Chairman, District 1
E. J. Humphrey, District 2
C. E. Blackman, District 3
J. C. Cloman, District 4
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A. J. Watson, County Supervisor

Honorable Pauline L. Davis, California State Assembly, 2nd District

L. G. Armond, Plumas Sierra Farm Bureau
Robert Dellinger, Quincy
Pete Ferios, President, Quincy Ski Club
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Harry Lutz, Rancher
Earl C. Pederson, Owner, Forest Lodge Resort, Greenville
Karl W. Traylor, Director, Chamber of Commerce, Lakes Basin
Blairsden Area
Sturgis Whitwell, Portola Chamber of Commerce

For assistance at conferences in estimating recreation demand, the supply of recreation areas and facilities to meet this demand, and the recreation potential of the upper Feather River Basin:

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A. Graham Atkins, Sacramento District U. S. Army Corps of Engineers

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RECREATION BENEFITS FROM THE UPPER FEATHER RIVER BASIN DEVELOPMENT

PART I. INTRODUCTION AND SUMMARY

The demand for public outdoor recreation has outstripped the development of California's great natural outdoor recreation resources. Population growth will continue to be one of the most significant factors influencing this demand, but the importance of population growth will be compounded by higher real incomes, more leisure time, and improved transportation which will increase the mobility of the population and its ability to enjoy recreational activities.

The development of outdoor recreation facilities in California is inadequate to meet safely present demand. Statewide recreation use increased from 2 visitor-days per capita in 1941 to 2.4 days in 1956. During this time the total use of national forests in California doubled from 14,475,000 visitor-days in 1941 to 31,074,000 in 1956. This increase in use has resulted in overcrowding and overuse of older established outdoor recreation areas in the state. Many recreationists who prefer the relaxed quiet charm of the "great outdoors" have been forced to look to new areas to satisfy their desires.

California's population is expected to increase to 45 million at "ultimate" development by the year 2050, and projections indicate that growth will equal about one-half this figure by 1970. Conservative forecasts indicate that outdoor recreation use will increase to at least 10 annual visitor-days per person in the state at ultimate development.

It must be assumed that public policy will require the expansion of outdoor recreation facilities to provide adequately for present and increasing future demands. The development of every suitable outdoor recreation area will be necessary to meet future demand. The full resources of federal, state and local governments, semi-public organizations, and private individuals will be required to accomplish this task.

This study of recreation benefits from the Upper Feather River Basin development must be placed in the context of anticipated population growth and resulting state outdoor recreation requirements related to the potential for recreation development in the Upper Basin. This little known, undeveloped and unspoiled area is one of great natural beauty, variety of terrain, lakes and streams, and attractive tree cover.

Recreation has played an increasing role in the economic development of the natural resources of the Upper Feather River Basin. The decline in mining, reductions in manpower requirements for timber harvesting, and corresponding population losses have forced the residents to look toward the development of the area's great outdoor recreation resources as the foundation for a revitalized economy.

The Upper Feather River Basin will contribute substantially toward meeting the statewide requirements for outdoor recreation, irrespective of recreation development related to water projects in the area. Planned and protected public and private recreation development of these water areas will permit substantially greater use without destroying the basin's prime purpose as a timber and water producing area.

With increased pressure of use throughout the state, the rate of development in the Upper Basin can be expected to be very rapid and exceed the rates of growth of both population and recreation use of California's national forests and national parks. Already there are signs of increased recreation activity, and plans for recreation development to meet this demand are reaching the construction stage.

OBJECTIVES AND SCOPE

In 1956, under contract with the Department of Water Resources, studies were inaugurated of present and projected recreation use in the Upper Feather River Basin, both with and without water projects then under investigation. Eleven proposed reservoirs were included, as follows: Grizzly Valley, Antelope Valley, Abbey Bridge, Dixie Refuge, Frenchman, Squaw Queen, Sheep Camp, Nelson Point, Meadow Valley, Genesee Valley and Indian Falls. The first five reservoirs were studied and findings outlined in summary fashion in the Department of Water Resources Bulletin No. 59. These reservoirs are now authorized for development.

In May 1957, these studies were substantially enlarged to conform with the most recent investigations of the Department and to provide comparisons of alternate schemes of development on the Middle Fork of the Feather River. The character of the studies was again changed in September 1957, when continued engineering investigations by the Department of Water Resources demonstrated the doubtful engineering feasibility of Genesee Valley and Indian Falls reservoirs.

In addition to the five authorized reservoirs, the following nine reservoir areas were studied: Squaw Queen, Sheep Camp, Turntable (known previously as Nelson Point but changed to avoid confusion with Richvale Irrigation District's proposal), Meadow Valley, Swayne, Humbug and the two Richvale Irrigation District proposed reservoirs of Nelson Point and Clio. Genesee Valley was studied as a potential State Park with the development of a smaller reservoir at the upper end of the valley. Studies comparing the effect of Richvale Irrigation District and Department of Water Resources plans on future recreation use of the lower Middle Fork of the Feather River were also included.

While the number of study areas have thus increased, the following objectives and scope of the studies for the entire Basin and the methods used in economic evaluations of designated reservoirs have remained constant:

1. Determination of the relative magnitude of the demand for outdoor recreation in California and the Upper Basin as reloted to projected population growth and other factors and trends affecting outdoor recreation demand.

2. Assessment of present and the ultimate potential for recreational use of the Upper Feather River Basin without additional water development and with state water development.

3. Through an analysis of each reservoir area, utilizing illustrative site development plans controlled by basic planning principles and standards, determine the increase or loss in recreation use resulting from the water development program under study.

4. Develop standards, principles and processes to accomplish the evaluations and devise an acceptable method for expressing direct recreation benefits in economic terms.

5. Determine relative benefits and costs to feasibility standards for public recreation facilities for each reservoir area resulting from construction of projects under study.

Economic feasibility studies of necessity consist of a series of projections based on existing conditions and controlled by reasonable assumptions, criteria and acceptable standards. The total structure of economic feasibility contains population and related recreation demand projections for the State and Basin, number of visitor-day public recreation use determined for each study area both with and without additional water development, the costs directly resulting from public (camp and picnic) development and use, and relating the total net benefits to total net costs to determine relative economic justification. The projections and findings used in this study are considered conservative and yet reasonable because of the following controlling factors:

- o Since population growth is the most important single factor affecting recreation demand, use of the mean projection between high and low forecasts, when recent studies by the Bureau of the Census and the State Department of Finance indicate that the high forecast will be exceeded, attest to the conservative nature of recreation demand estimates for both California and the Upper Feather River Basin.

Further, present use figures in the national forests and parks, the prime basis for demand projections, were recorded under overload conditions with users competing for available facilities.

- o General site plans for each of the thirteen recreation areas and recreation projections based on anticipated land use in the full study area recognize the prime purpose of the basin as a watershed timber producing area. Principles and standards controlling site plans and land use densities are compatible with this purpose by limiting the intensities of use according to the ability of the land to stand the pressure of use.

- o Potential recreation use is measured in visitor-days which in turn is the number of days each type of recreation facility would be used in relationship to capacity at one time. The number of visitor-days anticipated, therefore, would vary with the density of development and intensity of use of planned facilities. Balanced public-private recreational land uses controlled by high planning standards and conservation principles have resulted in relatively conservative visitor-day projections to determine dollar benefits. The projected densities and intensities of use are conservative in light of observed conditions in the basin and comparable recreation areas.

- o The economic evaluation of individual study areas consists of the application of a dollar value to each visitor-day of public recreation use and the comparison of total benefits thus gained to total net costs attributable to public development and use to determine economic justification. Critical to this comparison is the derivation of the quantitative value of a visitor-day. The controls set both to simplify the process and to rationalize the two-dollar benefit figure selected have resulted in a value that could be criticized from the standpoint of being conservative. Further lessening of this value resulted from the use of 1956 data in determination of the quantitative benefit, while 1958 costs were used for the proposed projects.

SUMMARY OF FINDINGS

The purpose of the physical and economic evaluations, summarized in the following sections, was to determine the economic feasibility of public recreation developments in conjunction with possible water development programs in the Upper Feather River Basin.

Statewide Recreation Demand

Levels of economic development and population growth determine recreation demand, with population as the most significant factor. Trend patterns indicate that the state of California and the Upper Feather River Basin will reach ultimate development between the years

2020 and 2050. At that time:

- o Population will have increased to 375,000,000 in the United States and 45,000,000 in California:

- o Economic conditions will have continued to improve resulting in:

  a shorter work week and more leisure time,

  median family incomes will at least double those at present,

  increased life span, earlier retirement and assured life incomes will permit selection of attractive living environment and more recreational activity,

  improvement and extension of transportation routes and mode of transportation will increase mobility;

- o Recreation demand and use of outdoor recreation areas and facilities will increase at a ratio related directly to population but at a rate geared to economic, social and technological improvement resulting in:

  increase in recreation visits to all national forests and national parks in the United States from 96 million in 1944 to 1.4 billion by 1962,

  increase of recreation visitor-day use of national forests and national parks in California from 35.6 million in 1955 to 450 million at ultimate development (total visitor-day use including other public and private areas will appreciably exceed this figure),

  increased use of existing areas will force rapid development of new areas such as the Upper Feather River Basin to meet state and national demand.

Recreation in the Upper Feather River Basin

Recreation is expected to expand during the period of study from its present relatively undeveloped stage to the major industry in the Upper Feather River Basin.

Approximately 70 percent of the Upper Basin is within national forest boundaries, consisting of all of Plumas National Forest and parts of Lassen and Tahoe National Forests. The major source of historical data to determine trends of recreation use are the records of

Plumas National Forest. Recreation use and development of privately owned lands was determined by a field survey and personal interview survey conducted by Pacific Planning and Research in 1957. This survey covered 115 privately-owned or operated facilities. These and other sources of data are the basis for the assissment of present recreation use and the projection of demand.

- Present Recreation Use:

  Total visitor-day use of Plumas National Forest increased over 400 percent in the five-year period of 1950 to 1955 -- from 342,500 visitor-days to 1,421,851. Public camping and picnicking facilities in 1955 were used almost 70 percent beyond their safe, healthful use capacity.

  Based on the field survey and national forest and national park data, use of the full Upper Basin in 1956 totaled 3,199,000 visitor-days.

- Future Recreation Demand in the Upper Basin:

  It is assumed that future recreation demand and use in the Upper Feather River Basin will continue at its present ratio with recorded trends for Plumas National Forest which contributed about 50 percent of total use in 1956. It is likely that Plumas National Forest will have a relatively rapid build-up of use, but as the area approaches ultimate development the rate of increase will roughly parallel that of other national forests and parks.

  At ultimate development Plumas National Forest should receive at least 10 percent of total statewide demand or 45 million visitor-days. Recreation demand in the full Upper Basin will approximate 132 million visitor-days, of which some 30 million will be contributed by persons driving through the area but not using developed facilities.

Projected recreation demand, based on trends, is a statistic unrelated to the amount of developable land, best land use, or the prime purpose of the basin. Sound management practices and programs conserving timber and watershed resources and achieving fish and wildlife enhancement must be applied to maintain recreation attractiveness, and these factors set the limits on plans of development and on the "ultimate" potential for recreation use of the Upper Feather River Basin.

General planning principles, criteria and standards for specific types of recreation use, facilities and areas were developed to assure that use of planned recreation areas would be compatible with the prime purpose of the Basin. Recreation use estimates based on these controlling factors related to best land use adequately reflect the effect of water development and are a more realistic evaluation of ultimate recreation use in the Upper Basin than the trend, or statistical, demand projections.

- Ultimate recreation use without additional water development:

  Many existing recreation areas in the Basin can absorb higher densities of development, and major increases in use without additional water development, therefore, will result from more intensive use of existing and other presently undeveloped areas. A total of some 79,000 acres will be developed for intensive recreation use, compared to the present 2,603 acres.

  Almost one-half of the ultimate recreation use will be oriented to rivers and stream areas, with camping and picnicking facilities furnishing 50 percent of the annual visitor-days use, summer homes 23.6 percent, resorts 22.1 percent, and organization camps 7.1 percent.

  Potential safe use of the Upper Basin without additional water development, based on a general plan related to best land use and conservation principles, will approximate 62 million visitor-days plus some 31 million highway "user" visitor-days. Forecasted demand would exceed such safe use by more than 64 percent. If this condition is permitted to occur, it will seriously endanger the watershed timber producing capabilities and the continued recreation attraction of the Upper Basin.

- Ultimate recreation use with State water development:

  Construction of proposed State water projects would double the existing water surface area and shift the predominant use orientation from river and stream areas to reservoirs and lakes. The additional reservoirs and enhanced downstream areas, with controlled firm water releases permitting increased use of these areas for fishing and other recreation, would create a more even distribution of recreation attractions and activities over the entire basin.

  The increased water areas would permit the development of 50,300 more acres for recreation use. With more developable area, visitor-day use can be increased without increasing either the intensity of use or the average densities of developed areas. This additional use can be maintained through the preservation of ample open space and utilization of the "cluster" design principle suggested and illustrated on the reservoir site plans.

With State water development the Upper Basin can safely accommodate almost 95 million annual visitor-days use which would generate about 47 million visitor-days by people driving through to enjoy the forest scenery and environment. Forecasted demand would exceed safe use with State water development by less than 11 percent as opposed to 64 percent without additional water development.

Construction of State water projects, and the development of recreational facilities, therefore, will be necessary to meet forecasted demand in a safe, desirable, healthful and uncrowded manner. Such development would be consistent with the prime purpose of the Basin and will permit the continued maximum enjoyment of its natural resources and great recreational opportunities by the people of California and the nation.

Recreation Use of Reservoir Areas

A summary of the evaluation of recreation benefits and costs on the five authorized projects was included as " Appendix A" of the Department of Water Resources Bulletin No. 59, February 1957. Illustrative site plans and a summary of the benefit-cost analysis were included in that report, but the description or evaluation of the recreation areas as a basis for the site plans on which benefits and costs were determined was omitted because of space limitations. These factors are fully presented in Part IV of this report. The authorized units incluse the Indian Creek Recreation Project and the Frenchman and Grizzly Valley projects.

Nine reservoir areas under investigation consisting of Squaw Queen, Sheep Camp, Turntable, Meadow Valley, Genesee Valley Park, Swayne, Humbug, Nelson Point and Clio areas were studied and general site plans prepared. The plans were evaluated to determine the relative benefits and costs accruing from the construction and operation of public recreation facilities projected for each area. The description of each area, the basis for the public and private facilities projected, and the number of units by type of recreation facility are discussed in detail in Part IV and will only be reviewed in this summary.

Based on the site development plans, net benefits and costs attributable to and resulting from the public recreation use and construction of each reservoir recreation area were developed for the fifty-year payout period. Unit capital construction and operation, maintenance and replacement costs for the public recreation facilities and necessary roads were applied to determine incremental yearly costs from 1961, the assumed date of reservoir completion, and 2010, the end of the payout period.

Net visitor-day figures were derived as the difference between the use generated by public facilities <u>with</u> the construction and operation of the reservoirs and the use projected <u>without</u> construction and operation of the reservoirs. Dollar benefits obtained from recreation use were computed by the application of the quantitative benefit of $2.00 per visitor-day to this net increase in use. Both the benefit and cost totals were adjusted to present worth, and converted to average annual equivalent figures. These average annual equivalents were directly related to each other to produce a benefit-cost ratio for each of the recreation areas under study.

o Authorized Reservoirs:

The Indian Creek Recreation Project in the Upper Indian Creek Basin is located in a mountainous area in northeastern Plumas County. The area, in spite of natural scenic beauty and suitable climate characteristics, now receives only limited recreation use. The project will include the three reservoirs or Antelope Valley on Indian Creek, Dixie Refuge on Last Chance Creek and public recreation facilities in each reservoir area.

The projects of Frenchman on Little Last Chance Creek and Grizzly Valley on Big Grizzly Creek are located in the upper drainage of the Middle Fork of the Feather River in the eastern portion of the Basin. Both projects will furnish irrigation water to Sierra Valley, downstream flood control, and recreation benefits within their reservoir areas.

These authorized reservoirs were reported upon in 1957 before full analysis or research data and the results of the field survey had been completed. Analysis of these data indicate that public recreation use estimated at that time was about 67 percent of probable use, and the benefits and costs for the five authorized projects have been re-evaluated to reflect this increased use as follows:

> The total cumulative probable net increase in use resulting from water development of the five study areas would approximate 12.2 million visitor-days during the 50-year payout period resulting in estimated total net benefits of 24.5 million dollars.
>
> Total cumulative capital and operating costs at 1956 prices for the combined areas studied is 6.1 million dollars.
>
> A favorable benefit-cost ratio of better than 3 to 1 for each area, with a total ratio for the five projects of 3.5 to 1, justifies public expenditures for construction of public outdoor recreation facilities at each of the reservoirs.

o Reservoir Areas Under Study

Squaw Queen Reservoir Area, located at the confluence of Last Chance and Squaw Queen Creeks, is in the Northeast portion of the basin a few miles drive from the authorized units of Antelope, Dixie Refuge and Abbey Bridge. The strategic location of the area, length of shoreline, good tree cover, variety of topography and a large amount of developable land permits maximum development for balanced recreation use. Operation of the reservoir, with a normal pool of 2,700 acres, for power production will not seriously affect recreation use.

> The developmental plan utilizes 4,025 acres of land for public and private facilities with a total of 6,050 four-person units, 1,900 acres of which are for public camping and picnicking facilities.
>
> Probable annual visitor-day use of all facilities will exceed 1.5 million by the year 2050, while use of public facilities alone will equal 640,000 visitor-days annually.
>
> Net cumulative probable visitor-day use for the payout period will exceed 6.4 million, resulting in a public benefit of over $12.9 million. Net cumulative costs at 1958 prices is less than $3.7 million. The resulting favorable benefit-cost ratio is better than 3 to 1.

Sheep Camp Reservoir Area is located in the southeastern portion of the Basin on the west side of Sierra Valley. The lake will be some three miles long with a water surface of 1,630 acres at normal pool elevation. The development of a well balanced recreational area is permitted by the variety of topography, tree cover and a favorable recreation environment. The location of the reservoir adjacent to State Highway 89 only two miles from the summer home community of Calpine assures demand for recreation development of this reservoir site.

> The developmental plan identifies 1,605 acres for public and private recreation facilities. Probable annual use of public facilities is estimated at over 320,000 visitor-days by 2050, while total probable use of both public and private facilities is about 700,000 visitor-days.
>
> The Sheep Camp project will increase recreation use by more than 4 million cumulative visitor-days over the payout period resulting in a net benefit of over $8 million. Cost of projected public facilities at 1958 prices is approximately $2.3 million. The benefit-cost ratio is better than 3.3 to 1.

Turntable Reservoir Area, on the Middle Fork of the Feather River, is about 8 miles southeast of Quincy. Located about 12 miles downstream from Sloat, the dam would back water some 6 miles in the deep Middle Fork Canyon and some 2 miles along Nelson Creek canyon. The steep canyon walls and rugged topography limit road access to an area just upstream from the dam on the Quincy side of the 640 acre reservoir. Many smaller potential camping and picnicking sites can be reached by foot or by boat. The topography requires that much of the area be retained in its original state which will preserve its outstanding "outdoor" characteristics.

> The development plan calls for a total of 1,534 acres for all recreation purposes with 183 acres for camp and picnic areas. Public facilities will accommodate over 3,600 visitors per day with probable annual use of approximately 300,000 visitor-days.
>
> Construction of public camp and picnic facilities at Turntable is justified with a benefit-cost ratio of better than 3 to 1. A cumulative net increase of 3.2 million visitor-days over the payout period will result in a net benefit of $6.5 million opposed to net costs of slightly over $1.9 million at 1958 prices.

Meadow Valley Reservoir Area, located on Spanish Creek some three miles upstream from Quincy, has ample tree cover and a variety of scenic advantages and topography suitable for all types of balanced recreation development. The dramatic eastern face of Spanish Peak rises to 3,100 feet from the generally square shaped shore line. The reservoir, which will have a surface area of 5,750 acres, will contain one large island over a mile long and one-half mile wide as well as some smaller islands, all developable for varying recreation uses. Its immediate proximity to Quincy and U. S. Highway 40 Alternate, its scenic advantages and the natural features of the reservoir itself make this area one of the most promising in the Upper Basin for recreation development.

> Some 3,700 acres can be developed for all types of recreation use of which 1,700 are planned for public uses. At full development the area can accommodate over 22,000 persons per day with 7,000 of these in public camping and picnicking facilities.
>
> Net visitor-days use of public recreation areas will be increased by a cumulative total of over $13 million during the fifty-year payout period. Net increase in capital and operating costs of public areas is estimated at $3.7 million which compared to benefits results in a favorable benefit-cost ratio of better than 3 to 1.

Genesee Valley Park Area includes all of picturesque Genesee Valley which is about eight miles southeast of Taylorsville in the central portion of the Upper Basin. The developmental plan is related to full utilization of the non-fluctuating 675 acre reservoir and Indian Creek with a regulated full stream flow running the full length of the valley. Public recreation facilities are concentrated on the valley meadow near the water attractions. Park concepts controlled the design of the area to include an amphi-theatre, a nine-hole golf course, some resorts, and administration, control and other service facilities.

> The plan designates 280 acres for camping and picnicking facilities and 140 acres for resort establishments. A total of some 12,600 people can be accommodated per day, 11,200 of whom will be in public facilities. Ultimate use will exceed one million visitor-days annually with over 950,000 in public areas.

During the payout period cumulative visitor-days use of public areas will exceed 11.4 million resulting in a benefit over $22.8 million. Total capital operating costs of all public installations is estimated at $9.3 million using 1958 prices.

In spite of the higher standards and resulting additional costs, the development of Genesee Valley as a park is economically justified with a favorable benefit cost ratio of 2.3 to 1.

Swayne Reservoir Recreation Area is located on French Creek about three miles upstream from its junction with the North Fork of the Feather River in the southwestern portion of the Upper Basin. The reservoir will have a normal pool of 2,550 acres, and its operation for power production will not seriously affect its recreation use. The ruggedness of the terrain naturally reserves open space between developable areas assuring an uncrowded development. It is anticipated that the natural beauty and ample tree cover and its proximity to Oroville reservoir will accelerate its recreation development.

Out of the 1,000 developable acres, only 165 are suitable for public recreation facilities because of the rugged terrain. Some 730 acres on the steeper slopes overlooking the reservoir are designated for summer homes, which will be in demand because of the area's nearness to the population centers of the Sacramento Valley. More than half of the 500,000 ultimate annual visitor-days will be generated by the public recreation areas.

Public investment in these facilities is justified with a favorable benefit cost ratio of 2.8 to 1. Cumulative net benefits will be over $4 million opposed to net costs of $1.3 million during the payout period.

Humbug Reservoir Recreation Area is located on Yellow Creek north of its junction with the North Fork of the Feather River near Belden, but it is most accessible from State Route 89 via Prattville on Lake Almanor. The 1,790 acre reservoir will be comparatively shallow, and its operation for power production will not adversely affect the recreation development and use except in dry years. The developable area consists of gentle slopes rising from the shore line with adequate tree cover for balanced recreation development. The nearness to the established Lake Almanor recreation area is expected to increase its rate of development and use.

Approximately 1,300 acres can be developed ultimately for all recreation uses, 140 acres of which will be for public recreation facilities. Public facilities can accommodate 2,800 visitors per day with probable annual use of 238,000 visitor-days out of the total for all facilities, public and private, of 530,000.

A net cumulative public benefit of over $4.2 million will be generated by the more than 2 million visitor-day increased use resulting from reservoir construction. Net costs of public facilities are in excess of $1.2 million. Development according to the general plan would provide facilities that are economically justifiable for state construction with a benefit-cost ratio in excess of 3 to 1.

Nelson Point Reservoir is proposed by Richvale Irrigation District as an alternate for the State's Turntable Reservoir. The two reservoir sites would differ only in that the Nelson Point dam site is some two and one-half miles farther downstream. The area between the two dam sites is extremely precipitous. Most of the additional development would be located on the canyon rims overlooking the reservoir, and would utilize foot trails and the dam maintenance road for access to the water.

Some 230 additional acres are indicated for recreation development on the Nelson Point plan, bringing the total to 1,766 acres with 237 acres used for camp and picnic areas. Slightly more than 12,350 visitors per day can be accommodated at ultimate development and approximately one-third will use public facilities creating a probable annual use of over 400,000 visitor-days.

During the fifty-year payout period cumulative net increases in public use of Nelson Point will exceed 3.6 million visitor-days, the resulting net benefit will be over $7.2 million, and net costs will approach $2.2 million at 1958 prices. The benefit-cost ratio of providing public recreation facilities will approximate 3 to 1.

Clio Reservoir Recreation Area is located some three miles upstream from Blairsden on the Middle Fork of the Feather River. Adjacent to the dam site is the recreation community of Graeagle. The town of Clio and the existing route of State Highway 89 will be inundated by the impounded water which will flood all of the upper portion of scenic Mohawk Valley. The tentative operation schedule of the reservoir for supplementary storage of water for hydroelectric power generation at Nelson Point downstream indicates the drawdown at the end of the recreation season will not seriously affect recreation use, but the normal pool of 2,200 acres will be reduced during drawdown periods exposing mud flats which will curtail recreation development.

> Some 1,400 acres of suitable terrain with tree cover are available for balanced recreation development, including both public and private facilities. The 165 acres set aside for public use will accommodate 3,300 visitors per day with total annual probable use of 289,000 visitor-days at ultimate development.
>
> Cumulative fifty-year public benefits will equal $4.3 million resulting from a net increase in public use of in excess of 2 million visitor-days. Net cumulative increases in costs of public facilities will approach $1.4 million during the payout period. The resulting benefit-cost ratio exceeds 2.8 to 1.

The relative standings of the fourteen study areas show wide variety in net visitor days and net costs found for each recreation area. These differences result from the physical characteristics of each area, size and operation schedules of each reservoir, general location of the area and its relationship with other recreation areas in the Basin, and the amount of developable land suited to both public and private use within the area. The summary of these recreation areas in Table 1 while demonstrating this difference in benefits and costs, indicates that public expenditure for the costs of public facilities is economically justified for each area.

Potential Recreation Use of the Middle Fork of the Feather River

The analysis of existing and potential recreation use of the Middle Fork of the Feather River includes comparisons of development proposals by the Richvale Irrigation District and the California Department of Water Resources.

Land that can be developed for recreation in the Middle Fork of the Feather River is very limited in area and relatively inaccessible. Steep canyon slopes along the stream beds and the surrounding area often reach 50 percent, while sheer rock cliffs rise from the bed of the river and constitute obstacles to travel along the river bottom. Below Sloat the Middle Fork is

1. SUMMARY OF PUBLIC RECREATION BENEFIT-COST RATIOS OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010, BASED ON PROBABLE VISITOR-DAYS USE

Reservoir Area	Net Visitor Days	Net Benefit	Net Cost	Adjustment to Present Worth Benefit	Adjustment to Present Worth Cost	Annual Present Worth Equivalent Benefit	Annual Present Worth Equivalent Cost	Benefit Cost Ratio
Authorized Projects			(1956 Prices)					
Grizzly Valley	2,916,490	$ 5,832,980	$ 1,445,175	$ 2,263,133	$ 623,220	$ 87,967	$ 24,224	3.631:1
Antelope Valley	2,502,460	5,004,920	1,211,895	2,025,247	565,814	78,721	21,993	3.579:1
Abbey Bridge	2,449,100	4,898,200	1,272,150	1,927,306	566,832	74,913	22,032	3.400:1
Dixie Refuge	1,943,900	3,887,800	978,490	1,602,930	469,921	62,305	18,265	3.411:1
Frenchman	2,430,010	4,860,020	1,299,740	1,901,588	537,062	73,914	20,875	3.541:1
Sub-total (1)	12,241,960	24,483,920	6,137,450	9,720,204	2,762,849	377,820	107,389	3.518:1
Proposed Projects			(1958 Prices)					
Squaw Queen	6,493,870	12,987,740	3,689,343	4,926,390	1,494,754	191,489	58,101	3.295:1
Sheep Camp	4,027,080	8,054,160	2,274,019	3,134,104	934,827	121,823	36,337	3.352:1
Turntable	3,286,860	6,573,720	1,913,049	2,554,572	794,717	99,296	30,890	3.206:1
Meadow Valley	6,578,230	13,156,460	3,707,149	4,966,820	1,486,463	193,060	57,779	3.341:1
Genesee Valley Park	11,422,710	22,845,420	9,341,293	8,744,700	3,793,079	339,906	147,437	2.305:1
Sub-total (2)	31,808,750	63,617,500	20,924,853	24,326,586	8,503,840	945,574	330,544	2.861:1
Swayne	2,009,400	4,018,800	1,306,252	1,533,155	535,284	59,594	20,806	2.864:1
Humbug	2,136,680	4,273,360	1,257,951	1,586,114	498,396	61,653	19,333	3.182:1
Sub-total (3)	4,146,080	8,392,160	2,564,203	3,119,269	1,033,680	121,247	40,139	3.021:1
Richvale Projects								
Nelson Point	3,631,180	7,262,360	2,277,174	2,843,456	946,152	110,525	36,777	3.005:1
Clio	2,160,730	4,321,452	1,398,051	1,697,504	585,978	65,982	22,777	2.897:1
Sub-total (4)	5,791,910	11,583,812	3,675,225	4,540,960	1,532,130	176,507	59,554	2.964:1
Total (1) & (2)	44,050,710	88,101,420	---	34,046,790	---	1,323,394	---	---
(2) & (3)	35,954,830	72,009,660	23,489,056	27,445,855	9,537,520	1,066,821	370,683	2.878:1
(1), (2) & (3)	48,196,790	96,493,580	---	37,166,059	---	1,188,068	---	---

accessible to conventional passenger cars only at Nelson Point and Millsap Bar. Some jeep trails and foot trails, both over steep slopes, have not been maintained sufficiently to prevent or lessen dangerous access to the river bottom.

The concepts controlling the development plans for the Middle Fork preserve this limited access feature and the wilderness nature of the area. They also recognize that fishing is and should remain the prime attraction to those who wish to attempt the physical exercise necessary in using the projected hiking and riding trails. Consequently, water releases into the river from both development proposals are assumed to be sufficient to maintain both the fishing resources and the attractiveness of the stream.

o <u>Present and Ultimate Recreation Use Without Additional Water Development:</u>

Existing recreation facilities in 1956 in the Middle Fork area consisted of a 12-unit Forest Service campground at Millsap Bar and some 20 permanent or summer homes scattered along the canyon. Ultimate recreation use of the Middle Fork without water development necessarily assumes that future stream flows will continue unregulated, affecting accessibility and stream-side access to usable areas.

> Recreation developments in 1956 received an estimated 16,000 visitor days recreation use. In addition is the unrecorded use generated at primitive or undeveloped camping areas located in the more accessible and usable areas along or above the river.
>
> A minimum of 225,000 annual visitor-day use and a probability of 337,000 annual visitor-day use would be generated by camping and picnicking facilities by the end of the fifty-year payout period. This use would result from stage development of some 980 camp and picnic units in developable areas along the 42 miles of river stream bed and the 26 miles of live streams flowing into the river from the upper end of either Turntable or Nelson Point reservoirs to Oroville Reservoir.

o <u>Ultimate Recreation Use With State Water Development:</u>

The Department of Water Resources study plan for the development of the Middle Fork of the Feather River consists of Turntable Reservoir, a diversion to Meadow Valley Reservoir, Meadow Valley Reservoir, and alternate diversions either to Belden on the North Fork or Hartman Bar on the Middle Fork. This combination of reservoirs and diversions constitutes the Meadow Valley Plan.

The general recreation plan for the Middle Fork has permitted stream bed access only by hiking and riding trails, and on strategically located jeep trails for service or emergency purposes. The State proposal permits a continuous streamside foot trail system along the 35 miles of stream channel with existing rock outcroppings, primitive foot bridges, and shallow dams to cross the river at points where sheer canyon walls prevent continuous access along one side of the river bed.

It is contemplated that private resorts with clusters of public and private recreation development and private service facilities will be constructed along the canyon rim and will offer provisioning for those seeking access to the more primitive recreation areas of the canyon. Future public and private recreational development for the Meadow Valley and Turntable Reservoir recreational areas was based on illustrative site developmental plans. The facilities provided in these plans are the basis for the projection of recreation benefits from the Meadow Valley Plan.

> Public recreation in the total Meadow Valley Plan, including Meadow Valley Reservoir, Middle Fork of the Feather River, and Turntable Reservoir, indicate a probable net cumulative total annual visitor-day use for the fifty-year payout period of approximately 14.5 million, with a minimum visitor-day use of over 10 million.
>
> Total recreation use, including both public and private for the Meadow Valley Plan, shows a 40 million probable and 25 million minimum net cumulative increase in visitor-days use for the fifty-year payout period.

o Ultimate Recreation Use With Development of Richvale Irrigation District Plan.

The Richvale development proposal consists of Clio and Nelson Point Reservoirs, Minerva Bar, Dogwood Bar, Hartman Bar, and Bald Rock Canyon diversion dams and diversion tunnels. All the water developments are located on the Middle Fork. Clio Reservoir would be used to supplement the water stored at Nelson Point Reservoir. From Nelson Point Reservoir the water would pass through tunnels to the various diversion dams and eventually into Oroville Reservoir. The Richvale Plan suggests the type of development which presently exists on the North Fork of the Feather River, but it is assumed that water releases into the river will be properly controlled to maintain the recreation attraction of the Middle Fork.

Net increase in cumulative total annual visitor-day use for the fifty-year payout period resulting from the Richvale Irrigation District water development over no additional water development for public recreation areas indicate a probable 9.3 million visitor-days use, and a minimum of 6.4 million visitor-days use can be expected.

Total public and private development net increases in cumulative visitor-days use from the Richvale proposal would be a minimum of 17.6 million visitor-days, and a probable visitor-day use of 28 million at the end of the fifty-year payout period.

o Comparison of Middle Fork Plan:

At ultimate development the Meadow Valley Plan would create slightly more recreation use than the Richvale Plan considering only the Middle Fork Canyon and Turntable and Nelson Point Reservoirs. Clio and Meadow Valley Reservoirs significantly alter the comparative relationship of the total development of each proposed system.

The total State Meadow Valley Plan would safely accommodate 30 percent more people at one time, and 53 percent more annual visitor-day use than the total Richvale Plan at ultimate development.

The Meadow Valley system indicates that by the year 2050 the probable annual visitor-day use will be over 4,880,000 in contrast to the total Richvale system of some 3,180,000 annual visitor-day use.

PART II. DEMAND FOR OUTDOOR RECREATION

Recreation, as an industry, has been ranked third in the United States, exceeded only by manufacturing and agriculture.[1] The importance of wholesome physical exercise, inspiration, enjoyment of the outdoors, and relaxation to the well being of the people is well recognized and accepted. All studies and projections point to greater demand for outdoor recreation throughout the country. The natural resources of the Upper Feather River Basin are uniquely well suited for "outdoor" recreational activity.

Recreation demand depends on the levels of population and economic development. These factors in California are influenced by and closely related to those of the nation. In turn, they also affect recreation use and development in the Upper Feather River Basin. Population growth is believed to be the most significant factor influencing recreation demand.

POPULATION GROWTH

Population estimates for the State and the Nation are the basis for projection of future recreation use.[2] Trends and patterns of economic development and population growth indicate that the Upper Feather River Basin will reach ultimate development between the years 2020 and 2050 based on potential development of the natural resources of the area, the projected growth of state and national populations, and expected changes in employment patterns of the state and the Upper Basin in light of established long term trends. The year 2050 was selected to represent probable "ultimate" or full development of the area's resources, and population growth was projected to that year.

1. U.S. Forest Service, Operation Outdoors, 1957. p. 1, source: National Association of Travel Organizations.
2. Pacific Planning and Research, formerly Harold F. Wise and Associates, "Future Population, Economic and Recreation Development of California's Northeastern Counties", Appendix A of Bulletin 58. Northeastern Counties Investigation; State of California, Department of Water Resources, Division of Resource Planning; July, 1957.

The population forecasts of the United States and California for the year 2050 are subject to wide variations because of the many factors that may accelerate or retard growth. The most logical approach to the problem was judged to be: (1) determination of the range within which the population can be expected to vary in the year 2050, and (2) adoption of a figure near the middle of this range. High, low and mean projections of the total populations of the United States and California were developed, and are shown by ten year intervals from 1900 to 2050 in appendix Tables A-1 and A-2.

All estimates and forecasts at ultimate development assume no major disaster, such as a devastating war, epidemic or other catastrophe will occur during the forecast period. It should be stressed that the forecasts presented in this report are the product of the assumptions about future conditions on which they are based. They indicate what appears likely to occur, not predictions of what will occur.

The 1956 population of the United States was 168,091,000 people according to the Bureau of the Census. By the year 2050, projections show that this population will increase to about 375 million, with a possible range from 300 to 450 million.

California's 1956 population, estimated by the State Department of Finance, was 13,600,000 people or slightly over 8 percent of the national population. This figure is expected to increase to between 26 and 46 million over the next 50 years. In 2050 California's population could range between 32 and 58 million with a "mean" projection of 45,000,000 people. At that time about 12 percent of the nation's population will be living in California.

In effect, the high and low forecasts represent a reasonable upper and lower limit for the population of the United States and California in the year 2050. It is impossible to predict whether the population of California in 2050 will be close to the upper or lower limit of the indicated potential range. It appears entirely possible that this ultimate population figure might be reached at any time after the year 2020.

The latest revised population estimates for the United States and California published in 1957 by the U. S. Bureau of the Census and the California Department of Finance indicate that the "high" forecast could well prove to be a conservative estimate at the present rate of growth.

FACTORS INFLUENCING RECREATION USE

Recreation visits to outdoor areas have increased at a much faster rate than the population of the United States and California. The assumptions about future population growth, based on expected improvements in social and economic conditions, will also have a definite affect on future recreation demand. Recreation use will be influenced not only by increasing population but by technological developments in industry, transportation and communication, and improvements in conditions and increased productivity of labor leading to higher standards of living with more leisure time. These factors will make it feasible for many persons to recreate in "outdoor" areas while their business and permanent residence is elsewhere.

An important element affecting the magnitude of outdoor recreation activity is personal income that will be available to finance its enjoyment. With continuing social and economic advancement, it is expected that average personal income will increase. Recent trends indicate that the average work-week and the average work-year will become shorter in the future, resulting in more "free time". All these trends, therefore, point toward more goods and services, more leisure time for people to travel, and more money for them to spend on recreation. The expansion of highway programs, improvement and extension of transportation routes, and improved modes of transportation will increase mobility. Construction and improvement of more access roads and development of reservoirs will create additional points of entry into forest areas and provide many more areas for general recreation as well as hunting and fishing. These stimulants to recreation use are already being felt in many forest areas.

Demand for "outdoor" recreation areas will continue to be equated to physical capabilities of these areas to meet adequately the preferences of all kinds of recreationists. Thus, the potential of outdoor recreation areas is the controlling factor limiting recreation use. As the pressure of population growth increases, every suitable area with reasonable recreation attraction will be required and used for recreation purposes irrespective of developmental conditions.

Historical records of visits to national forests show the effect of national disasters such as World War II. From the prewar peak of about 18 million visits to all national forests in 1941, recreation use dipped to about 6.2 million visits in 1943. It was not until 1946, when 18.2 million visits were recorded, that prewar levels of use were re-established. In California's national forests similar trends were observed, but prewar visitor-day use levels were exceeded in 1945.

National outdoor recreation use steadily increased during the period of economic depression of the '30's, although not at the same rate as the rapid increase since the war. "It seems clear that increased recreation use of national forests is encouraged by high national income and employment, but takes place even under unfavorable economic conditions".[1] It is assumed, therefore, that recreation use can be expected to increase irrespective of economic conditions, but the rate of increase and the dollar expenditures of recreationists will be in

1. Marian Clawson and Burnell Held, The Federal Lands - Their Use and Management (John Hopkins Press, 1957) p. 73.

relation to such conditions.

TRENDS IN RECREATION USE

Recreation visits to all the national parks and national forests in 1955 totaled 96,000,000 - a national increase of 140 percent over 1946. On a per capita basis, recreation visits more than doubled from 1946 to 1955. By 1962, recreation visits to the nation's "outdoor" recreation areas are expected to increase to 1.4 billion.

In California, visitor-days use of the national forests and national parks have grown from 23,085,000 in 1946 to 35,614,000 in 1955 -- an increase of 54 percent. Camping and picnicking alone have increased 81 percent in the last five years, while state population increased only 36 percent during this period.[1]

Demand for "outdoor" recreation facilities is perhaps even greater than the above figures indicate. Existing developed recreation facilities in the state and the nation are inadequate to provide safe use. For example, the nation's camping and picnicking facilities in the national forests in 1955 had a safe, uncrowded, healthful capacity of about 17,600,000 annual visitor days. Actual use was 25,500,000 visitor days resulting in an overload on the available facilities of 39 percent. At the rate of construction permitted by available funds this overload was expected to increase to 61 percent by 1958. The Forest Service estimates it will be 1962 before adequate facilities can be provided under the "Operation Outdoors" program.

The National Park Service, faced with similar problems, is developing the "Mission 66" pro-

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1. U. S. Forest Service, "Recreation in the California National Forests", California Recreation Commission, Tenth Annual Report, Ten Years of Progress 1947-1957, February, 1958. p. 84.

gram which proposes to develop and staff all areas managed by the National Park Service, "... in order to permit their wisest possible use and the preservation of scenic, scientific, and historic resources which give them distinction".[1] The State Park Commission has stated conservatively that "... during the past several years, the demand for camp and picnicking sites has far exceeded supply, and this will undoubtedly continue for some time in the future".[2]

Camping and picnicking facilities in national forests in California were used to about 78 percent of their safe capacity in 1946. By 1950, the percentage of use increased to 87 percent. Then, with the intensity of use in 1955 almost 50 percent higher than for 1950, facilities were used to 131 percent of their safe capacity. Almost 4,000 additional camping and picnicking family units should have been provided to meet safely the 6,814,000 visitor days use the available facilities actually received.

The deterioration of camping and picnicking facilities accelerated by over-use has reduced the number of available facilities. Instead of lessening demand or use, the apparent inadequacy of facilities has resulted in overcrowding of developed areas and increased use of unimproved areas which lack sanitary facilities and fire prevention improvements.

An indication of the magnitude of the trends in recreational use of reservoir recreation areas can be gained from the experience of the U. S. Army Corps of Engineers which has approximately 50,000 acres of reservoir land and water areas available for recreation use of corps projects in California. Activities include boating, fishing, camping, picnicking and golfing.

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1. National Park Service, "National Parks and Monuments", California Recreation Commission, Ten Years of Progress, 1949-1959, op. cit. p. 84.
2. California State Park Commission, Five Year Master Plan, July 1, 1956 to June 30, 1961. (March 1, 1956) p. 9.

Expenditures of about $2,700,000 in federal and non-federal funds were made for construction of basic recreation facilities at the reservoirs over the past decade. From 1947 to 1957, the number of visitor days has increased from about 60,000 to 2,150,000 - a 3,843.3 percent increase.[1]

Per capita use of outdoor recreation facilities in California is expected to increase rapidly, stimulated by higher incomes, a shorter work-week, longer vacations, improved transportation, and the other benefits of an expanding technology. California must continue to prepare and provide for the needs of anticipated population growth. In addition, the state must also prepare for a large influx of out-of-state visitors. In 1953, for example, there was one out-of-state tourist for every three California residents.[2]

Total visitor days use of Plumas National Forest, which covers about half of the Upper Feather River Basin, increased over four times in the five years from 1950 to 1955. Recreation use declined somewhat in 1956 "... because of highway and Pacific Gas and Electric Company construction. Highway conditions and traffic controls discouraged some travel".[3] Even so, visitor days use in 1956 alone equaled two-thirds of the combined use for the five years of 1946 through 1950.

The intensity of use of the available recreation facilities in Plumas National Forest increased from 44.3 annual visitor-days per person that could be accommodated in 1950 to 94.3 in 1955. During this period the intensity of use of camping and picnicking facilities was three times

1. U. S. Army Engineer Division, Corps of Engineers, "Recreation Developments", California Recreation Commission, Ten Years of Progress 1947-1957, op. cit. p. 89.
2. Kenneth Decker, The Tourist Trade in California, Bureau of Public Administration, University of California, 1955.
3. Plumas National Forest, Annual Statistical Report, Recreation Visits, 1956 (Preliminary)

greater from 42.7 to 144.2 visitor days per person of capacity. In 1950 these facilities were used to about 51 percent of their safe, healthful capacity, and, only five years later, they were inadequate by 69.7 percent.

The trends in recreation use of national forests and national parks provide a measure of statewide outdoor recreation use of the type which will occur in the Upper Feather River Basin. They also reflect Forest Service policy regarding recreation development which is motivated by natural resource, timber management and conservation principles. The recreation resources of the national forests are made available for public use and enjoyment, to the degree that this is consistent with the overall management of the national forests for the greatest public good.

Public recreation areas and facilities such as camping and picnicking are provided by the Forest Service. Organization camps and public service facilities such as restaurants, resorts and motels, are not constructed by the Forest Service but by competent individuals or organizations encouraged to develop them under special use permit in locations where there is a public need for such facilities and services. Preferential private uses, such as summer homes, are permitted only where lands are clearly not needed for public use.[1]

The Forest Service has concentrated its efforts on public recreation facilities, which is reflected in the available records. Demand for other types of outdoor recreation facilities has also been met to some degree on privately owned lands adjacent to national forest boundaries, and it can be reasonably assumed that this pattern will continue. Unfortunately, however, historical data of all statewide recreation use is not available. Recreation use on privately owned land should be recognized as an important part of the complete picture.

1. U. S. Forest Service, Operation Outdoors, 1957, p.6.

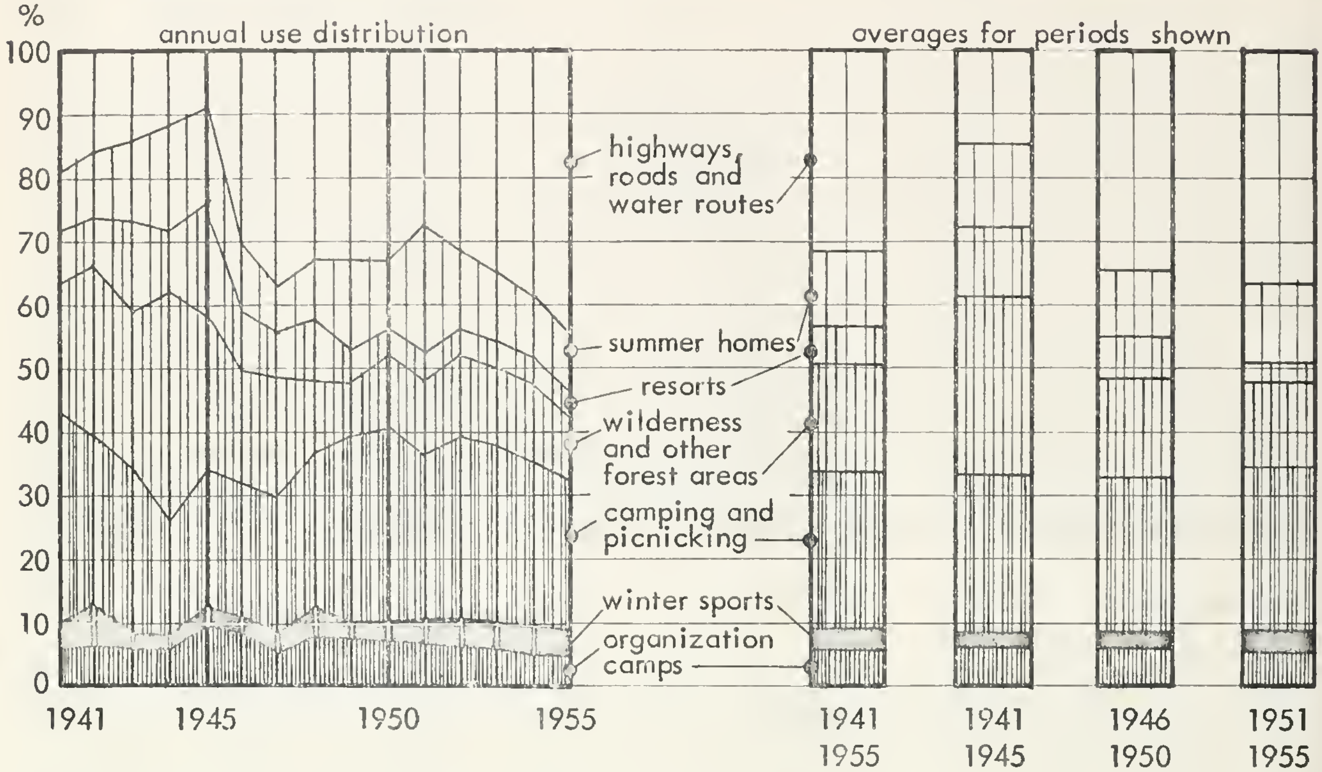
The distribution of visitor-day use of national forests over the period of record provides some measure of the trends in recreationists' preferences for each of the eight different catagories of recreation use recorded by the Forest Service. This distribution, however, does not consider the demand which might have been satisfied on privately owned lands or the demand which was discouraged because of inadequate facilities. The trends in use distribution provide a point of reference for estimating future demand for various types of recreation use. There are many unforeseeable factors, such as future Forest Service policy, which could affect future distribution. The graphs which follow give some idea of the relation of one use to another. Annual percentages of distribution of visitor-days by type of recreation use for national forest lands in California and Plumas National Forest are shown in appendix Tables A-3 and A-4.

There is considerable fluctuation from one year to the next in the use distribution of California's national forests. Over the past 15 years, an average of 31 percent of total visitor-day use has been in the form of highway users, or persons "driving through" the national forests to enjoy the scenery and environment. Persons driving through are not presently counted as users of public recreation facilities, but in many cases they may patronize private facilities adjacent to the national forests, such as hotels, motels, restaurants and stores. Visitor-day use in this classification has rapidly increased since wartime travel restrictions were removed in 1945, and this constitutes an important part of the total demand for recreation facilities. Of the total visitor-days less highway users, about two-thirds has been in public camping, picnicking, wilderness and other forest areas; one-third in resorts and summers homes; and one-twelfth in organization areas.

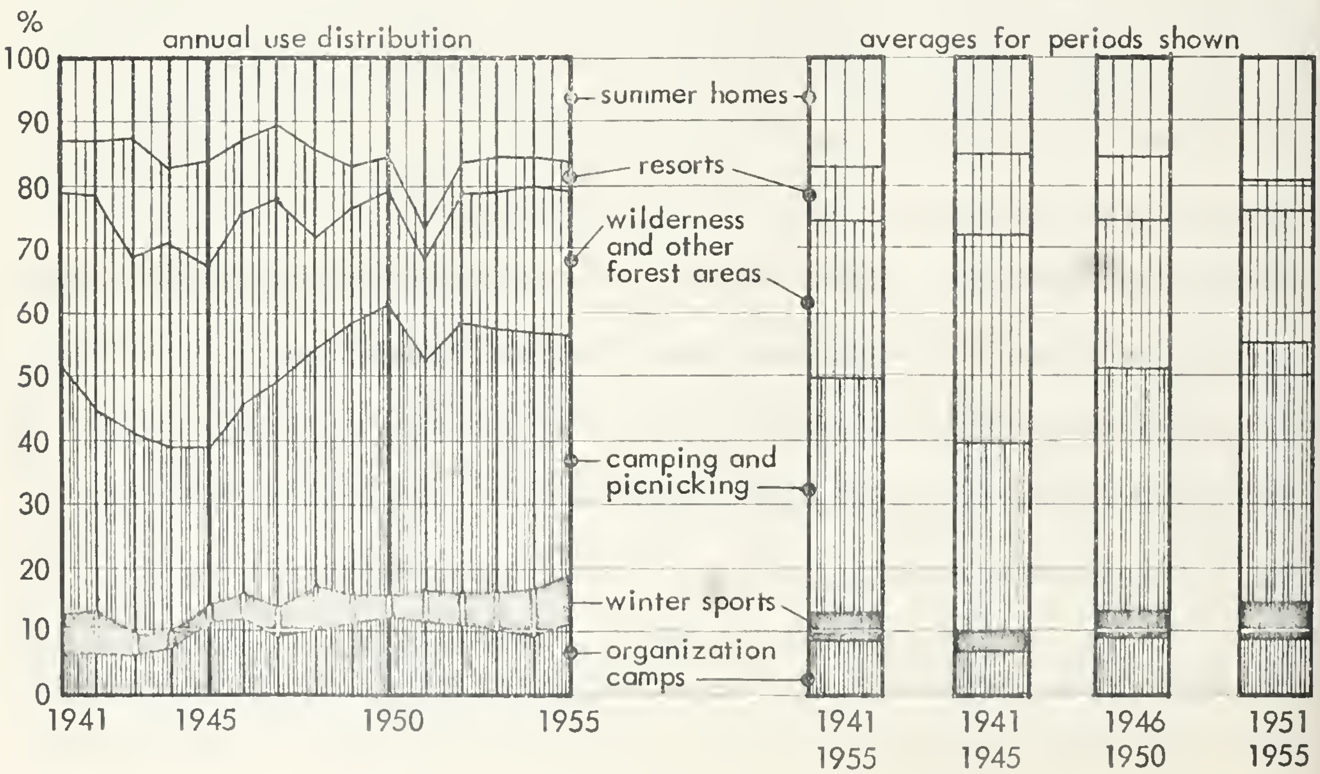
The percentages of use distribution for Plumas National Forest show a greater yearly fluctuation than for California's total national forests. The percentage of highway users more than

GRAPH 1. PERCENT DISTRIBUTION OF VISITOR-DAYS BY TYPE OF RECREATION USE NATIONAL FOREST LANDS IN CALIFORNIA, 1941-1955

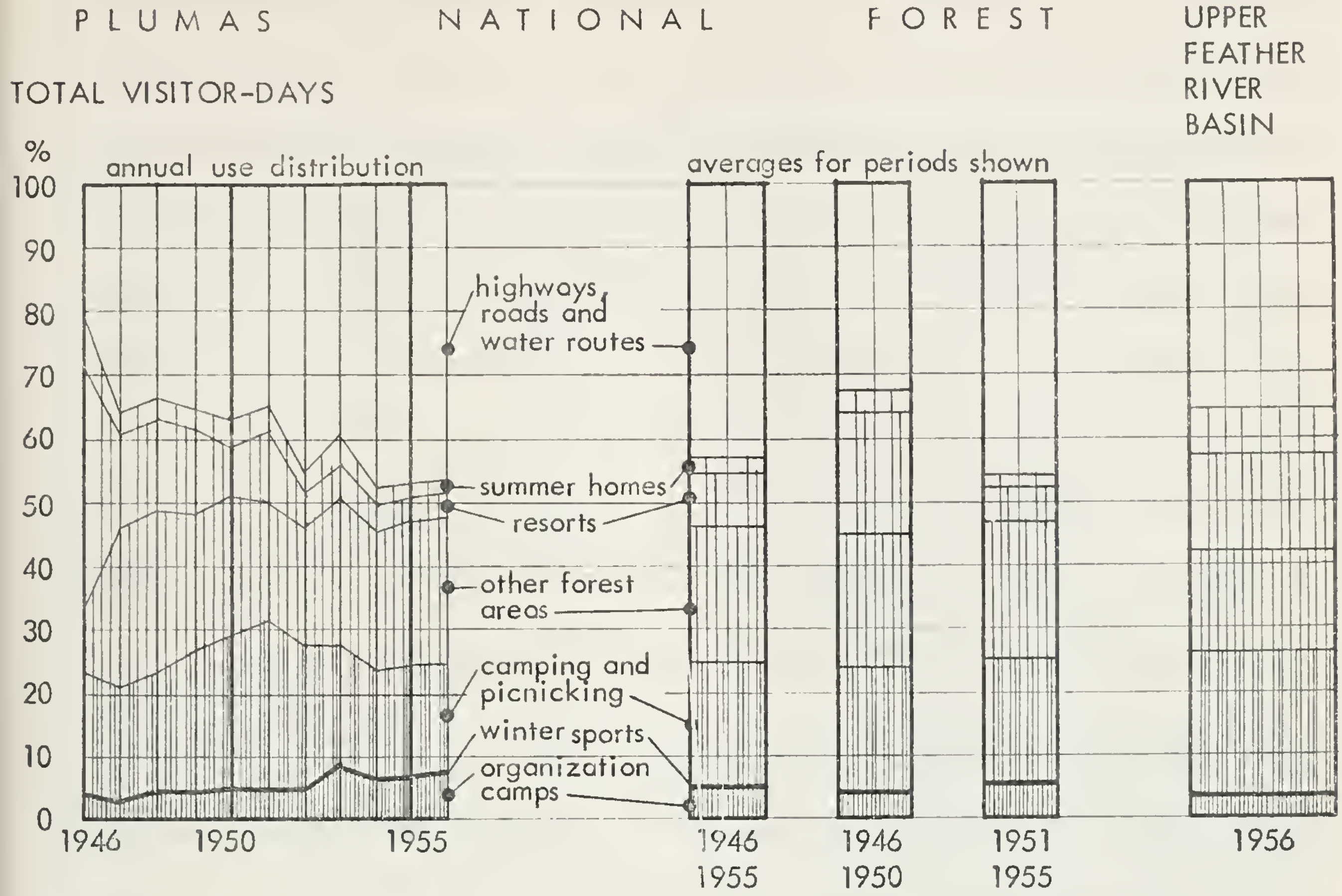
TOTAL VISITOR-DAYS

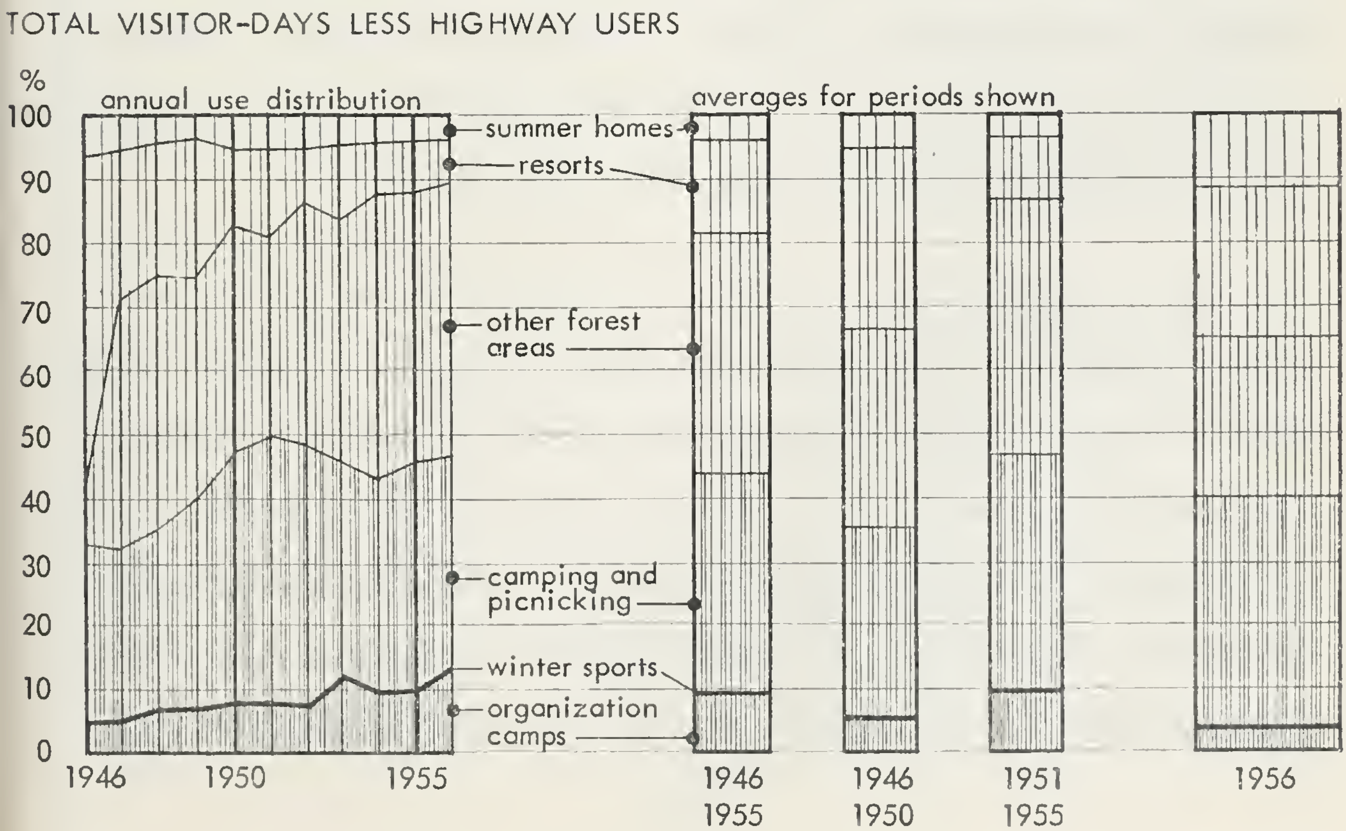


TOTAL VISITOR-DAYS LESS HIGHWAY USERS



GRAPH 2. PERCENT DISTRIBUTION OF VISITOR-DAYS BY TYPE OF RECREATION USE
PLUMAS NATIONAL FOREST, 1946-1956; UPPER FEATHER RIVER BASIN, 1956





doubled from 21.6 in 1946 to 47.7 percent in 1956 and averaged about 43 percent of total use. Over the 11-year period of record, about 41 percent of total use has been in public camping and picnicking and other forest areas; roughly 5 percent in organizational areas; and 10 percent in resorts and summer homes. The latter group has declined from 45.7 percent of total use in 1946 to 5.6 percent in 1956. Considering the Upper Basin, however, summer homes and resorts had about 22.3 percent of total use which indicates that a larger number of the facilities are being located on privately owned land. The period of record reflects a rapid build-up of facilities as well as use. The use distribution for the total basin in 1956 is almost the same as that for Plumas National Forest for the 1946 through 1950 period and for California's national forests for the 1951 through 1955 period.

STATE-WIDE RECREATION USE AND DEMAND

Use of California's great outdoor recreation resources has more than doubled in the past 15 years. A large percentage of these resources are within national forest and national park boundaries, which include the bulk of outdoor recreation areas in the state. Private recreation facilities, either located on Forest Service land by special permit or on adjacent private lands, also receive considerable use and benefit from these resources.

Forest Service records provide practically the only available historical annual record on which a projection of the trend of state-wide outdoor recreation use can be based. Reliable records of annual recreation use of California's national forests, measured in visitor-days, have been maintained since 1941. Visitor-day use figures for National Parks in California are available for the years 1946, 1950 and 1955 only. This data, shown below, provides the only basis, though limited, for estimating and projecting state-wide outdoor recreation demand in visitor-days. In 1946, recreation use was at a high level because of postwar "boom" conditions; 1950 reflects a "leveling off" period; and from 1950 to 1955 there was a rapid increase in use.

Table 2. California Visitor-days Use (in millions)

Year	National Parks	National Forests	Total	Per Capita Visitor-days*
1946	2,860	20,255	23,085	2.42
1950	3,690	15,195	18,885	1.78
1955	4,540	31,074	35,613	2.73

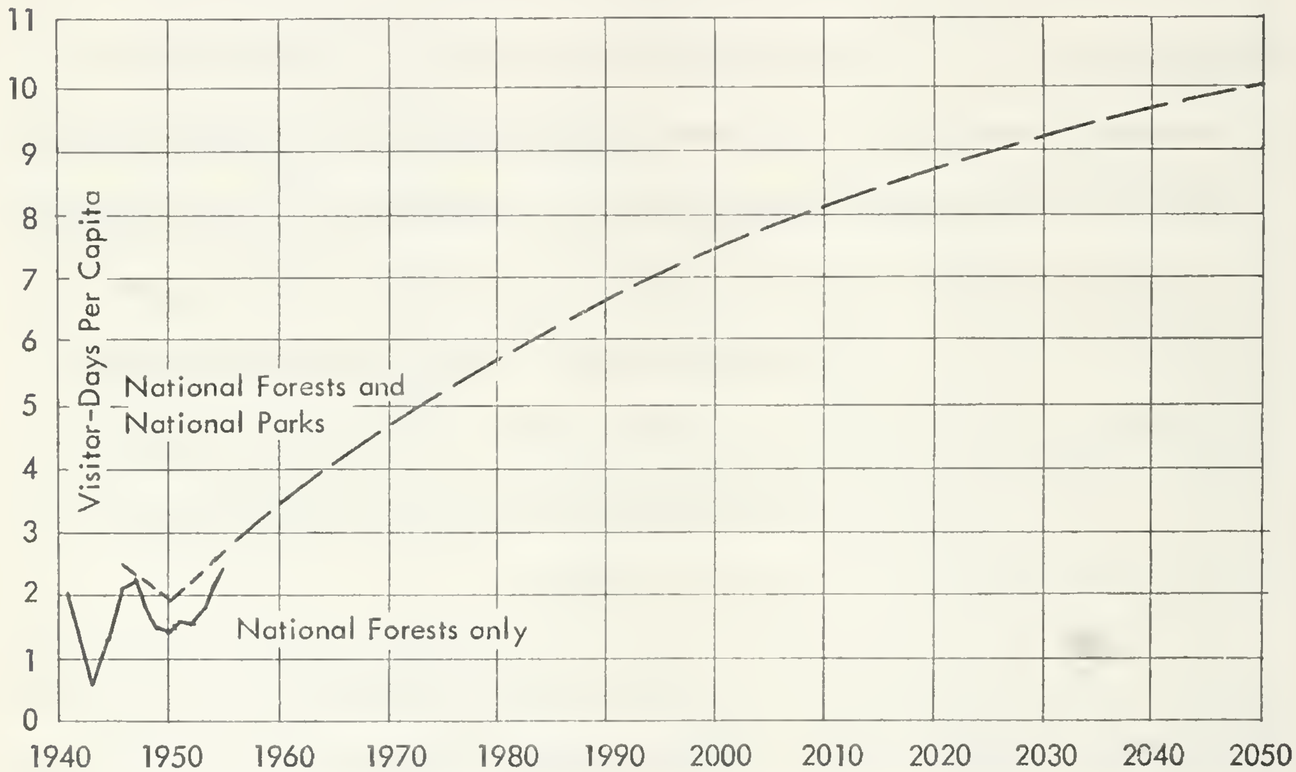
* Total visitor days divided by California's population.

Projections of per capita visitor-day use provide the most realistic long range measure of future recreation demand with the data presently available. Per capita use figures reflect the trends in social and economic change perhaps more accurately than any other available index. It can reasonably be assumed that recreation demand will generally follow population growth over the long run, but the level of recreation use may fluctuate above and below the mean projection depending upon economic conditions. Projections of per capita visitor-day use applied to projections of population growth provide a reasonable basis for measuring future state-wide outdoor recreation demand.

From 1946 to 1955 use increased 0.31 visitor-days per person in the State, or 0.031 visitor-days annually. The period from 1950 to 1955 shows a greater total increase of 0.95 visitor-days per person, or 0.16 visitor-days annually. Projection of the 1946-55 annual increase per capita use would equal 5.74 visitor-days per capita by 2050. The 1946-55 projection was considered as low and the 1950-55 projection as high. The resulting per capita visitor-day mean, or mid-point between the high and low, was 11.77. As in the case of population projections, future per capita visitor-days use could range anywhere between the low and the high. Projection of ultimate use by 2050 was based on 10 visitor-days per capita, which is conservatively below the mean.

A curve showing per capita visitor-day use of California's National Forests and National Parks was drawn to 2050. The initial portion of this curve reflects the high rate of increase from 1950-55 and tapers off to the mean at ultimate development.

GRAPH 3. PER CAPITA VISITOR-DAY USE, 1941-2050
NATIONAL FORESTS AND NATIONAL PARKS IN CALIFORNIA



The percentage of highway users in California's national forests has increased from 20 percent of total visitor-day use in 1941 to 44 percent in 1955. The mean from 1941 to 1955 is about one-third during the period of record and was assumed that the percentage of highway users will be about 33 percent by ultimate development.

The forecasts indicate a state population of 45,000,000 at ultimate development (Tables A-1 and A-2 of the Appendix). Demand for recreation use of national forests and national parks in California may reach 450,000,000 visitor-days at ultimate development compared with use of 35,000,000 in 1955. Excluding highway users, all other recreation users might approximate 300,000,000 visitor-days ultimately, compared with 22,750,000 visitor-days in 1955. These forecasts, from 1955 to 2050, are shown in Table 3. However, they do not include visitor-day use of private resorts and other types of private recreation facilities outside the national parks and national forests. Experience in the Upper Basin indicates that inclusion of this additional private use would increase these forecasts considerably.

3. RECREATION USE OF CALIFORNIA NATIONAL PARKS AND NATIONAL FORESTS 1941-1955 AND PROJECTIONS TO 2050.

Year	Total Visitor Days	Total Visitor Days less highway users	Year	Total Visitor Days	Total Visitor Days less Highway users
1941	14,475,541*	11,577,618*	1960	51,790,000	31,070,000
1942	9,460,150*	7,858,033*	1965	70,110,000	41,510,000
1943	5,004,130*	4,221,932	1970	87,800,000	51,800,000
1944	9,515,258*	8,301,035	1975	109,000,000	64,300,000
1945	15,640,901*	14,094,879*	1980	131,200,000	77,800,000
1946	20,225,025*	13,944,345	1990	178,400,000	107,600,000
	23,085,000	16,804,000	2000	224,100,000	137,100,000
1947	21,468,111*	13,196,249*	2010	271,400,000	169,600,000
1948	18,207,339*	11,947,251*	2020	317,000,000	201,300,000
1949	15,877,493*	10,663,130*	2030	362,300,000	233,700,000
1950	15,195,143*	10,130,178*	2040	407,000,000	268,000,000
	18,885,000	13,820,200	2050	450,000,000	300,000,000
1951	17,811,968*	12,750,393*			
1952	18,876,884*	12,723,868*			
1953	21,719,151*	14,153,333*			
1954	26,483,094*	16,525,006*			
1955	31,073,622*	17,216,556*			
	35,613,000	21,756,000			

* Includes National Forest only. All other figures include National Forests and National Parks. Source: U. S. Forest Service, Region 5, California 1941-1955, and National Park Service 1946, 1950 and 1955.

RECREATION USE AND DEMAND IN THE UPPER FEATHER RIVER BASIN

Approximately 70 percent of the Upper Basin is within national forest boundaries. Plumas National Forest is entirely within the basin and accounts for almost one-half of its area. Also included are parts of Lassen and Tahoe National Forests and part of Lassen Volcanic National Park. Presently developed recreation facilities in the basin include the areas around Lake Almanor, Bucks Lake and along the forks of the Feather River and the Lakes Basin Area. Many of these facilities are located on privately owned land.

Records of Plumas National Forest provide the only available historical trend of recreation use in the Upper Feather River Basin. These records, however, are also limited to facilities on Forest Service land. During the recreation season of 1957, Pacific Planning and Research conducted a survey of all recreation areas and facilities in the Upper Feather River Basin. The survey permitted first hand observation of the physical features and recreation attractions; and it provided factual data on present conditions and actual use of existing recreation facilities for 1956. The survey area included all of the Upper Basin, excluding Paradise, Challenge and Wyandotte Hydrographic Areas which constitute the remainder of the Service Area.

In 1956, a total of 115 privately owned or operated recreation facilities open to the public were field checked by Pacific Planning and Research. Operation personnel at each facility were interviewed and resulting data were recorded on a questionnaire form. A copy of the questionnaire is shown in the Appendix.

Data obtained from Plumas and Lassen National Forests and Lassen Volcanic National Park were used to estimate present use of public campgrounds, other forest areas and highway recreation areas. Present use of summer homes was estimated using data obtained from the two national forests, State Highway Planning Survey Traffic Maps, U. S. Geological Survey

Quadrangle Maps, Pacific Gas and Electric Company "Foreign Improvement Lists", U. S. Census of Housing 1950, "Occupancy Characteristics for Plumas County", field survey and personal interview. These data have been summarized for the upper basin and are shown in Tables 4 and 5 and by hydrographic units in Table A-5 of the Appendix.

4. RECREATION USE IN UPPER FEATHER RIVER BASIN, 1956

	Total	Camp and Picnic	Organization Camps	Resorts Hotels Motels	Summer Homes
Area in acres					
Basin total	2,293,700				
Developed	2,603	559	184	820	1,040
Number of facilities	1,197	63	11	89	1,040
Number of units	3,863	1,223	329	1,271	1,040
Capacity people	16,947	6,345	1,320	3,662	5,620
Capacity visitor-days	2,561,100	1,112,900	98,800	842,700	506,700
Visitor-days use	1,544,900	735,700	94,800	480,900	233,500
Average length of season (days)	151	175	75	230	90
Percent use	60.3	66.1	95.9	57.1	46.8

Existing recreation use clearly reflects the effect of water development on recreation development. All recreation development and use in the Upper Feather River Basin is oriented to water - rivers, live streams, natural lakes or man-made reservoirs. Accessibility and physical attraction are also important factors. The relation of present development to these factors is shown on Plate I, Existing Recreation Facilities.

Recreation development of the upper basin in 1956 consisted of 0.11 percent of the total area of the basin - only 2,603 acres out of a total of 2,293,700 acres. Summer homes utilize the greatest amount of land (1,040 acres), followed by resorts, motels and hotels (820 acres), camp and picnic (559 acres) and organization camps (184 acres). There are 63 camp-picnic installations in the basin and most of them (35) are owned and operated by the U. S. Forest Service. From the standpoint of actual users, camping and picnicking facilities had the greatest number and provided the most capacity in visitor-days.

5. RECREATION FACILITIES IN UPPER FEATHER RIVER BASIN BY HYDROGRAPHIC AREA
- 1956 -

	Total Upper Basin	42 North Fork	43 East Branch	44 Sierra Valley	45 Middle Fork	46 South Fork
Camp and picnic (total)	43	31	6	-	5	1
Privately owned	8	8	-	-	-	-
U. S. Forest Service	35	23	6	-	5	1
trailers not permitted	14	10	2	-	2	-
trailers permitted	21	13	4	-	3	1
Trailer Camps (total)	20	11	6	1	2	-
operated by resorts	11	9	-	1	1	-
commercial	9	2	6	-	1	-
Organization Camps	11	4	4	-	2	1
Resorts (total)	89	33	28	3	23	2
Lake resorts	15	13	1	-	1	-
Other resorts	36	11	5	2	16	2
Hotels	7	-	5	1	1	-
Motels	31	9	17	-	5	-
Summer homes	1,040	580	190	70	150	50
Total	1,197	659	230	74	180	54

Table 6 shows historical recreation use of Plumas National Forest from 1946 through 1956 and the data obtained from the survey of existing recreation areas and facilities in the Upper Feather River Basin. Plumas National Forest accounted for over one-half of the recreation use for the total Upper Feather River Basin in 1956. It is assumed that recreation use of the Upper Basin has increased at generally the same rate as that recorded for Plumas National Forest, and it is expected that this relationship will continue.

6. VISITOR-DAYS BY TYPE OF RECREATION USE, PLUMAS NATIONAL FOREST, 1946-1956 AND UPPER FEATHER RIVER BASIN, 1956.

Year	Total Visitor-Days	Highway users	Other forest areas	Winter Sports	Camp & Picnic	Org. Camps	Hotels & resorts	Summer Homes
Plumas National Forest:								
1946	402,390	87,000	40,880	775	75,370	14,380	161,185	22,800
1947	355,013	130,000	89,625	50	60,887	9,920	54,351	10,980
1948	337,475	116,500	89,200	100	61,735	13,520	47,750	8,670
1949	353,960	125,400	78,550	200	74,500	14,340	51,900	9,070
1950	342,520	131,040	76,160	150	83,450	14,380	26,180	11,160
1951	420,355	150,965	81,405	200	110,975	19,800	42,600	14,410
1952	626,440	298,000	119,665	1,500	139,225	22,650	30,440	14,960
1953	760,197	300,250	176,672	1,500	151,709	56,850	55,940	17,276
1954	1,283,678	653,037	278,496	1,400	208,425	64,500	59,250	18,570
1955	1,421,851	677,308	314,175	1,000	280,288	72,188	55,012	21,880
1956	1,181,200	565,000	255,000	300	220,900	74,000	47,000	19,000
Upper Feather River Basin:								
1956	3,199,000	1,138,800	514,000	1,300	735,700	94,800	480,900	233,500
Percent Plumas National Forest of Upper Feather River Basin:								
1956	36.9	49.6	49.6	23.1	30.0	78.1	9.8	8.1

In 1955, Plumas National Forest accounted for about four percent of total visitor-days use of all national forests and national parks in California[!] and, excluding highway users, its portion was 1.9 percent in 1946 and 3.4 percent in 1955 - an average annual increase of 0.5 percent. This annual increase, projected to the year 2050, indicates that Plumas National Forest might account for 18.1 percent of the total visitor-day demand for use of national forests and national parks in the State. The period of record, however, reflects a rapid build-up of recreation development and use brought about by the discovery by recreationists and developers of the area's recreation resources. During the immediate build-up period, Plumas National Forest will probably have a higher rate of increase in demand than the State's national forests and national parks as a whole. As the basin approaches ultimate development it is expected that the rate of increase will roughly parallel that of the state-wide increase. By ultimate development of the basin (2020-2050), Plumas National Forest should receive about ten percent of total visitor-day use of all national forests and national parks in Californis. Present use trends for Plumas National Forest indicate that the percentage of highway users will increase somewhat during the facilities build-up period and then decline at ultimate development to about 33 percent (roughly the present percentage of highway users in California's national forests).

In 1956, Plumas National Forest accounted for almost one-third of the Upper Basin's total visitor-day use excluding highway users. Projections of future recreation demand for use of the Upper Basin were developed on the assumption that the above relationship will remain constant in the future. Highway users for the basin were projected at twice Plumas National Forest highway use, using the area ratio of the Forest to the Basin.

7. ANNUAL VISITOR-DAYS RECREATION USE OF PLUMAS NATIONAL FOREST, AND UPPER FEATHER RIVER BASIN 1946-1956 AND FORECASTS OF DEMAND TO 2050.

	Plumas National Forest		Upper Feather River Basin	
Year	Total Visitor-Days	Total Visitor-Days Less Highway Users	Total Visitor-Days	Total Visitor-Days Less Highway Users
1946	402,390 a/	315,390 a/	---	---
1950	342,520 a/	211,480 a/	---	---
1955	1,421,851 a/	744,543 a/	---	---
1956	1,181,200 a/	616,200 a/	3,199,000 b/	2,060,000 b/
1960	2,640,000	1,476,000	7,258,000	4,930,000
1965	4,515,000	2,316,000	12,130,000	7,735,000
1970	6,286,000	3,212,000	16,880,000	10,730,000
1975	8,387,000	4,311,000	23,240,000	14,400,000
1980	10,670,000	5,525,000	28,740,000	18,460,000
1990	15,660,000	8,297,000	42,430,000	27,710,000
2000	20,090,000	11,380,000	55,440,000	38,020,000
2010	26,370,000	14,873,000	72,670,000	49,680,000
2020	31,500,000	18,521,000	87,810,000	61,860,000
2030	36,660,000	22,391,000	103,100,000	74,550,000
2040	41,500,000	26,381,000	118,100,000	88,110,000
2050	45,000,000	30,000,000	132,000,000	102,000,000

a/ Plumas National Forest, Annual Statistical Reports of Recreation Visits, for years shown.
b/ Based on field survey of Existing Recreation Areas and Facilities; 1956 and expanded to include "winter sports", other forest areas users, and highway users.

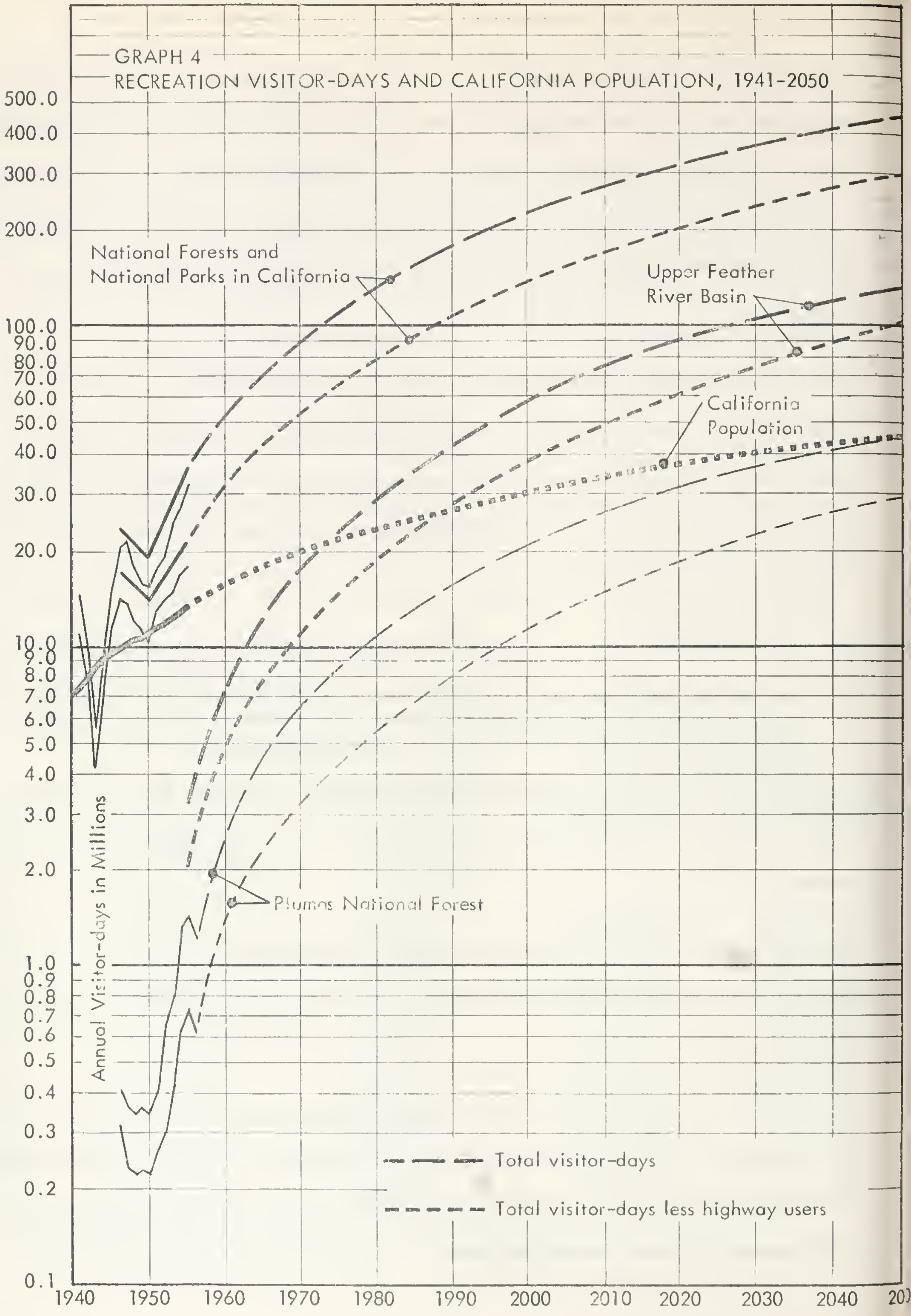
The projections of state-wide recreation use trends show that by ultimate development (2050) total visitor-days will have increased over twelve-fold in California's national forests and national parks. In addition, a similar increase in use can be reasonably assumed for other recreation areas outside forest boundaries. Total state-wide demand could exceed, perhaps by several times, the forecasted 450,000,000 total visitor-days for National Forest and National Park land in California.

Many existing recreation areas are presently overcrowded. New additional areas are needed to permit development of uncrowded, safe, healthful facilities in a desirable environment for present and future outdoor recreation use. The great recreation resources and scenic grandeur of the Upper Feather River Basin will continue to attract an increasing number of recreationists from all parts of the state and nation.

The forecast of ultimate recreation demand in the Upper Feather River Basin is well over three times the combined visitor-day use of all California national forests and national parks in 1955. On the basis of past growth, however, the forecast appears conservative. It may be difficult to visualize this increase in terms of the present development of the Upper Basin, but a century ago the present use of California's recreation resources may have appeared equally inconceivable.

The graph on page 42 shows the growth and forecasts of state population and recreation visitor-days for California's national forests and national parks, Plumas National Forest, and the Upper Feather River Basin.

Future outdoor recreation demand will depend on many presently unpredictable factors. The key factor, however, will be the actual development of the "ultimate" potentials. The next sections of this report deal with the determination of the possible, desirable and practical "ultimate" recreation use of the Upper Feather River Basin.


GRAPH 4
RECREATION VISITOR-DAYS AND CALIFORNIA POPULATION, 1941-2050
National Forests and National Parks in California
Upper Feather River Basin
California Population
Plumas National Forest
Annual Visitor-days in Millions
Total visitor-days
Total visitor-days less highway users
500.0
400.0
300.0
200.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040

PART III. RECREATION RESOURCES OF THE UPPER FEATHER RIVER BASIN

The forecasts of recreation use of the Upper Feather River Basin, developed in Part II, are a measure of future demand based on the projection of past trends. This demand must be evaluated against the "ultimate" potential of the basin, or its supply of recreation resources, in terms of the recreation planning principles, objectives and standards. This part will deal with resources and the following part with the standards and principles developed to protect and enhance these resources.

RECREATION RESOURCES OF THE UPPER BASIN

The recreation resources of the Upper Basin are described by hydrographic areas in the subsequent paragraphs.

Hydrographic Area No. 42 - North Fork, Feather River

This hydrographic area contains slightly over one-third of the area in the upper basin and is the largest of the five hydrographic areas in the basin. It covers the entire western side of the basin, and includes 94.8 percent of the water surface area within the basin. Perhaps this is why almost one-half of the recreation facilities in the basin are located in this area and these facilities received approximately 55 percent of the basin's visitor-days use in 1956. About 0.15 percent of the gross area is developed in recreation facilities. The present development includes all types of facilities, but camping and picnicking account for over half the use. Almost 70 percent of all camping and over half of the summer home facilities and use within the basin occur in this hydrographic area.

Existing water developments consist of Lake Almonor, Bucks Lake, Butt Valley and Mountain Meadows Reservoirs with a combined water area of 37,481 acres. These lakes and other facilities on the North Fork of the Feather River are owned by the Pacific Gas and Electric Company, and are used for hydroelectric power generation. Unfortunately, the water released from these operations have not always been compatible with good stream-flow maintenance practices. As a consequence, the recreation attraction of the North Fork of the Feather River as a fishable stream has been reduced. The resort operators and long-time residents of the area report that this river was, at one time, one of the best trout streams in the country. Fluctuation of the water level of the reservoirs resulting from power operation schedules has not appreciably lessened recreation use of the larger reservoirs, but neither has it increased recreation attraction. Fluctuation of stored water behind diversion dams, lack of developable land, and extreme slopes of the canyon walls preclude development and use of these areas for recreation purposes.

The North Fork area is accessible from U.S. Highway 40 Alternate, the "Feather River Route", which is cut into the steep slopes of the Feather River Canyon from Oroville to Quincy. State Route 89 connects U.S. 40 Alternate with Lake Almanor and the towns of Westwood and Chester. The northern portion of the area is traversed by State Route 36 from Susanville to Red Bluff via Chester and Westwood. Other county, Forest Service, and private roads provide access to almost every part of the area.

Caribou Wild Area and the major portion of Lassen Volcanic National Park are located in the northernmost portion of the North Fork area, and much of the remaining portion is within Lassen and Plumas National Forest boundaries. The area has long been used for timber production and this is expected to continue as timber is harvested on a sustained-yield basis. The major sawmill in the area is located at Chester. For many years, Westwood was practically a "company town" housing employees of the Red River Lumber Company. With the closing of this plant, Westwood virtually became a ghost town. Recently the old houses were sold and it has become a thriving summer home community almost overnight, and is now faced with problems of growth.

The North Fork area has many recreation attractions. There is variety in topography, vegetation, elevation and climate in combinations to satisfy almost all outdoor recreation interests. There are remote rugged scenic areas and large easily accessible areas suitable for intensive development. The area includes the proposed sites of Swayne and Humbug reservoirs which are evaluated in this report and a large portion of the authorized Oroville Reservoir.

Realization of maximum recreation opportunities in this area will depend considerably on the maintenance of suitable wildlife areas and fishable streams. Good stream flow maintenance programs must be adopted and followed. Existing water areas are capable of absorbing additional use, but some improvements are required. For example, the snags in Lake Almanor are a definite hazard to boating and water skiing activities and should be removed. All of the water areas should be controlled to permit all recreationists to fulfill their interests, whether it be pleasure boating, water skiing, fishing or swimming.

Hydrographic Area No. 43 - East Branch, Feather River

Second largest in area, the East Branch covers the central and northeastern portion of the basin and includes Indian and Spanish Creek drainage areas. Presently developed recreation areas are centered around Greenville and Quincy, the county seat of Plumas County. This development consists primarily of permanent and summer homes and hotel, motel, resort and commercial facilities catering to persons traveling U.S. Highway 40 Alternate and State Route 89. These facilities receive about one-fifth of the recreation use in the basin.

The area does not presently contain any major recreation attractions, but the presently developed areas are located within short driving time of almost any other area in the basin and serve as a "base of operations" for many recreationists. Easily accessible from Quincy are Bucks Lake and the rugged Middle Fork canyon at the proposed Turntable or Nelson Point reservoir sites.

There is considerable potential for recreation development within the East Branch area. Planned developments include the authorized Antelope Valley, Dixie Refuge and Abbey Bridge recreation reservoirs, and the study areas of Squaw Queen and Meadow Valley reservoirs, and Genesee Park. There is a variety of topography, cover, elevation and climate in the area which create an attractive background for recreation development and use. There is ample land suitable for development of all kinds of facilities, including possible winter sports development around Spanish Peak. Wildlife is abundant and many streams in the area are fishable. Stream flows from operations of the authorized and the the reservoirs under study would be desirable for increasing the fishing potential.

Hydrographic Area No. 44 - Sierra Valley

Hunting is the major recreation attraction of this area, and there is some scattered recreation development in the mountains surrounding the valley. The town of Calpine is developing into a retirement center and is showing signs of continued growth. Developed recreation facilities in Sierra Valley received less than 2 percent of the basin's visitor-day use in 1955.

The area is easily accessible from U.S. Highway 395, the "Eastside Sierra Route", via U.S. Highway 40 Alternate, and from Lake Tahoe, Donner Summit, and Yuba Pass via State Routes 89 and 49. The ease of motor vehicle access to nearby recreation attractions plus increased pressure of use in these other areas will unquestionably stimulate recreation development.

Agriculture is the predominant land use in the valley and this land is primarily in private ownership. Remaining areas are owned by Plumas and Tahoe National Forests.

Existing water development is on a small scale and is related to the irrigation and drainage of agricultural land. The authorized Frenchman and Grizzly reservoir projects are proposed for irrigation purposes, but they can be expected to receive recreation use proportional to the effects of water level fluctuation brought about by irrigation water release schedules.

Hydrographic Area No. 45 - Middle Fork, Feather River

The Lakes Basin area at the eastern end of this hydrographic area is one of the primary recreation attractions of the Upper Feather River Basin. No less outstanding in attraction, although undeveloped and somewhat inaccessible by motor vehicle, is the rugged Middle Fork canyon, running from Sloat to the confluence of the Middle and North Forks of the Feather River above Oroville. This hydrographic area received almost one-third of the visitor-days use of developed recreation facilities in the Upper Basin.

The upper portion of the Middle Fork canyon opens into Long Valley, Mohawk Valley and continues along Grizzly Creek to Grizzly Valley. These valleys are connected by and easily accessible from U. S. 40 Alternate, State Route 89 and the Western Pacific Railroad's trans-continental route. The Middle Fork canyon, however, is accessible by motor vehicle only at Nelson Point, Milsap Bar and Bidwell Bar. Access to other portions of the canyon is limited to jeep, hiking and horseback trails.

The Lakes Basin area has a long and colorful history beginning with the gold rush days. Several old mines exist around Johnsville, although mining activity has virtually stopped and the mines are deteriorating to the point of being unsafe. The area has been a popular resort area for over a quarter of a century. Recreation attractions include historic Gold Lake and numerous other smaller natural lakes and the Eureka Bowl winter sports area, which is being acquired for State Park development. Although the area is economically dependent on recreation use, the residents are concerned with the possibility that intensive recreation development would destroy the quiet atmosphere which gives the area much of its charm and attraction. There is good reason for this concern, and care should be exerted to insure the preservation of this atmosphere.

Blairsden, locale of the Feather River Inn, and Graeagle, Johnsville, C romberg and Sloat are rapidly developing recreation centers. The City of Portola at the upper end of the Middle Fork unit has been economically related to the Western Pacific Railroad. But here, as in the other communities, recreation is gaining in importance. The construction of State Water Plan projects will provide a definite boost to Portola's future growth and development.

Hydrographic Area No. 46 - South Fork, Feather River

Located in the southern central portion of the upper basin, this hydrographic area contains less than 5 percent of the land area in the basin. Developed recreation facilities received less than 3 percent of the basin's visitor-days use in 1956. The area is not served by improved major roads and access is somewhat difficult. Included in this area is Lexington Hill, site of the world's first competitive ski race which took place in February, 1869. This event was sponsored by the Alturas Snowshoe Club, which presently operates a rope-tow at this historic site and has revived interest in the development of the area's winter sports potential. The area is also rich in history of the gold rush days that influenced much of its present development.

Construction of proposed water developments along the Middle Fork of the Feather River and the authorized Oroville Reservoir may force the improvement of access roads. Construction of water projects in the South Fork basin would also contribute considerably to the potential recreation use of the area.

The Upper Feather River Basin includes Hydrographic Areas 42, 43, 44, 45, and 46, described above.

These areas plus three additional hydrographic areas: No. 41 - Paradise, No. 48 - Challenge, and No. 49 - Wyandotte, constitute the full Upper Feather River Service Area. These latter three units are combined under the heading of Foothill Areas and, although not included in the Upper Basin survey of existing recreation areas and facilities, they presently receive considerable recreation use. This use is expected to continue at an accelerated rate with the construction of Oroville Reservoir.

Foothill Areas

The Foothill Areas cover slightly over one-tenth of the total service area and include the City of Oroville and several unincorporated communities. Irrigated agriculture is the primary land use and this use will increase with abundant irrigation water made available from water development.

Rapid development of summer homes and motels around Oroville and Paradise reflects the probable future recreation use of the Foothill Areas. The foothills are the transition zone between the recreation attractions of the Upper Basin and the metropolitan population centers in the Sacramento Valley and the San Francisco Bay Area and will continue to be used as major points of entry into the Upper Basin.

MEASUREMENT OF POTENTIAL RECREATION USE

The analysis of the reservoir areas and the Middle Fork of the Feather River which will be discussed in Part V shows the effect of water development in increasing the recreation potential and use of particular areas. The development of these water projects and the resulting enhancement of downstream areas will cause a similar increase to radiate to other areas throughout the Upper Basin, the full Service Area, and perhaps even beyond the boundaries of these areas.

Procedures and methods of estimating the additional use beyond the immediate reservoir site areas were discussed and reviewed with the District Forest Ranger and his staff, county officials and private individuals. To determine possible recreation use, the entire Service Area was examined using Forest Service data, maps, aerial photographs and stereoscopic equipment in the Plumas National Forest Headquarters in Quincy. All areas which appeared to be suitable for types of recreation use were plotted on U.S. Geological Survey Quadrangle maps at scales of 1:62,500 and 1:24,000. These areas were measured, recreation standards applied, and the total number of recreation units, capacity people and probable visitor-day use tentatively determined.

It was concluded after this analysis that recreation development of all possible areas would not be compatible with the timber and water producing purpose of the Upper Basin and would destroy those features which make it attractive for outdoor recreation. Excessive amounts of land would be removed from timber production and open space would be unduly reduced.

Utilizing the illustrative site development plans, discussed in the next part, general recreation areas were defined and general standards determined to estimate the potential recreation use of the full Upper Basin and Service Area with and without water development. The method thus developed and finally used reflects the planning principles, objectives and standards used in the preparation of the site development plans. This general planning approach assures balanced land uses and the reservation of ample open, undeveloped space which accommodates relatively intensive recreation use with such uses as timber, water, and grazing in the Upper Basin.

General Recreation Area Classifications

The recreation resources of the Upper Basin can be classified on the basis of recreation attraction in terms of accessibility, physical features, existing and potential water development and natural resource management objectives. These classifications are described below.

o Nature Reserves - Remote areas of major recreation attraction which are inaccessible by vehicle because of terrain and remote areas of minor recreation attraction which are generally accessible by vehicle constitute this classification. Retention and preservation of the present character should be the recreation objective of these areas consistent with forest and range mangement objectives. There would be a minimum of recreation development in public picnic and camp facilities. Riding and hiking trails would be the principle means of traverse and access; where vehicle access is possible it would be controlled and not permitted to become extensive. Nature reserves are similar in character to primitive or wilderness areas except for size, vehicle access and roads. Except for some small areas, such as portions of the Middle Fork of the Feather River, the basin is presently accessible and traversable by vehicle. There is no single area in the basin which can be called a true primitive or wilderness area.

o Natural Areas - This classification consists of areas suitable for less intensive recreation development because of access and terrain limitations which are not as great as for nature reserves. Possessing recreation attractions of various kinds, these areas are adjacent to or provide access to major recreation attractions, although limitations of terrain are controlling. All types of recreation facilities are included but at lower density and lesser intensity than for the following classifications. Intensive development is discouraged to preserve the open "outdoor" character and scenic beauty.

- River and Stream Areas - Areas with rivers and live streams accessible by motor vehicle characterize this category. Good stream flow maintenance is necessary for recreation attraction. Some small lake basins are also included where it appeared that some fishing would be possible, and where intensive recreation use is not justified. All types of recreation facilities are included, and the development governed by the ability of the water area to absorb recreation use.

- Lake and Reservoir Areas - These areas are capable of intensive recreation development and use resulting from the attraction to bodies of water. In every case the areas are, or will be, accessible to vehicles and boats. All types of recreation facilities are included in proper balance as permitted by terrain. The open "outdoor" character is retained through design and density standards and emphasis is placed on public use of shoreline and water areas. Such areas will attract recreationists to the other recreation classification areas in the basin.

- Urban Areas - Areas with urban characteristics and use, house the resident population, and which are generally the centers of trade and commercial entertainment, are included in this classification. Intensive commercial recreation is foreseen for these areas, but camp and picnic and summer home areas are included in relation to the other surrounding recreation attractions.

- Winter Sports Areas - These areas have suitable snowfall, climate, terrain and are accessible by vehicle during the winter season. Such areas overlap the other recreation classification areas. Balanced recreation use with the inclusion of other recreation facilities is desirable during the summer season. It is anticipated that some nearby resorts, urban areas and summer home areas will be utilized as a result of the development of winter sports areas.

In addition to the preceding recreation area classifications, the classification of agricultural and open areas wos recognized. These areas are generally more suitable for other non-recreation uses or are not suitable for recreation use because of lack of attraction, land ownership patterns, or conflict with the best land use practices.

General Recreation Area Standards

Sample general recreation areas, based on the classifications defined above, were mapped, measured, and compared with the developable areas of the reservoirs and the Middle Fork. This comparison resulted in the derivation of the general recreation standards which are shown in Table 8, expressed as percentages of developable recreation area for each recreation area classification and per cent distribution of that developable area by type of recreation facility. Site development and use standards, discussed in Part IV, were applied to these areas to estimate the ultimate potential development and use.

8. PERCENT OF DEVELOPABLE RECREATION AREA OF EACH GENERAL RECREATION CLASSIFICATION AND PERCENT DISTRIBUTION BY TYPE OF RECREATION FACILITY AT ULTIMATE DEVELOPMENT, YEAR 2050.

General Recreation Area Classification	Developable recreation area percent	Percent distribution of developable area by type of recreation facility				
		Total	Camp & picnic	Org. zation	Resort	Summer home
Nature Reserves	0.0225	100	100	-	-	-
Natural Areas	3.5000	100	15	11	19	55
River & Stream Areas	7.0000	100	15	11	14	60
Reservoir Areas	25.0000	100	10	11	7	72
Urban Areas	20.0000	100	10	-	30	60
Winter Sports Areas	0.6000	100	-	-	100	-

It should be noted that the amounts of land for intensive recreation development are relatively low in proportion to the gross areas of each general classification. The areas not intensively developed for recreation would provide the necessary open space between recreation areas and preserve the outdoor recreation character. In addition, the undeveloped land would receive other multi-purpose uses such as timber production on a sustained-yield basis, grazing and other similar uses consistent with conservation and forest land management principles and practices. In urban areas, the land not developed for recreation would be used for residential, commercial, industrial and public facilities as required by both the resident and seasonal populations. In addition to developed facilities, the U. S. Forest Service uses two other recreation use categories - highways, roads and water routes and other forest areas. The nature of these classifications is such that estimates of potential visitor-days use intensity in terms of "safe, desirable, uncrowded and healthful" use is difficult if not impossible. Historically, these categories have accounted for the major portion of "outdoor" recreation use, and estimates of ultimate potential use of the Upper Basin would not be complete without including them.

Presumably, highway and other forest area users are either permanent residents of the area or those who recreate in the area but do not use the developed facilities (or who may use developed facilities on privately owned land and hence are not included as users of facilities in Forest Service tabulations). It is possible that users of developed facilities in national forests are duplicated to some extent in the recorded visitor-days use figures for these two categories.

The recreation activities of users of other forest areas include swimming, hiking, and gathering forest products for pleasure; but the primary activities are hunting and fishing. Safe use for hunting ultimately should be determined by the ability of the game to replenish, the number of hunters who can safely shoot game without harming each other or property and not destroy the natural habitat. Safe use of fishable streams probably would be determined by the number of anglers who can fish the stream without destroying its fishable use and character.

With the increased recreation attraction of the Upper Feather River Basin resulting from water or other recreation development, the use of other forest areas will increase accordingly. However, unless properly controlled, this use can pose a serious threat to management and conservation principles and objectives. Campers should be required to use developed campgrounds and "squatter" camps in the undeveloped portions of the upper basin should be prohibited, consistent with the management and conservation objectives and principles. Present trends indicate that potential use of other forest areas might equal about 42 percent of total visitor-days use less highway users.

It was pointed out in Part II that highway users, or persons driving through forest areas to enjoy the scenery and environment, constitute a major portion of the total recreation use. The problem of what consitutes safe, healthful, desirable highway use has perplexed traffic engineers, highway engineers, traffic enforcement agencies, pedestrians and the drivers themselves. If present trends continue, this problem will become even more perplexing. The available research indicates that at least a partial solution to this problem may be found in providing properly planned routes capable of carrying the traffic loads related to the present or future land uses - the real "traffic generators". It is assumed that these requirements will be met in the Upper Feather River Basin to permit safe accommodation of the anticipated highway users and other recreationists. It is estimated that potential use of highways, roads and water routes in the Service Area will approximate 33 percent of total visitor-days. It is recognized, however, that the actual percentage at ultimate development will be affected considerably by development and extention of transportation routes and possible improvement of the modes of transportation which cannot be foreseen over the course of the next century.

PART IV. RECREATION PLANNING PRINCIPLES, OBJECTIVES AND STANDARDS FOR THE UPPER FEATHER RIVER BASIN

The prime purpose of the Upper Feather River Basin should be recognized as the controlling factor in the ultimate development of its recreation resources. The character, geographic features and existing land use of the upper basin - its elevation and rugged topography, climate, rainfall, snowfall and its water and timber producing ability - unmistakably characterise the Upper Feather River Basin as a water and timber producing area.

The preservation of this purpose makes the upper basin attractive for outdoor recreation use - the lakes, live streams, big trees, mountains, clean air and open space. Development of recreation opportunities will require emphasis on safeguarding soil, vegetation, water and air.

Prior to the Northeastern Counties investigation estimation of the "ultimate" recreation potential of a large watershed area had not been attempted.[1] The methods used in the Northeastern Counties study were developed to cover several watershed areas and the resulting standards were related to the entire 15-county area as a whole.

Based on the knowledge gained in the Northeastern Counties study, a review of other possible methods and experience gained in the field survey, certain planning principles, objectives and standards were developed to reflect the special recreation characteristics of the Upper Feather River Basin. These principles and standards were applied in measuring potential recreation use, using a general land use planning approach, similar to that used by the Department of Water Resources in estimating irrigable lands and irrigation benefits.

1. Appendix A of Bulletin Number 58, Northeastern Counties Investigation, op. cit.

Analysis of past and present recreation in light of future demand provides a basis for developing the planning principles, objectives, criteria and standards which are necessary in determining the desirable ultimate recreation use of the Upper Feather River Basin. Experience and knowledge of the basin acquired in the course of the investigation shows that various areas of the basin have similar recreation attractions and capabilities for recreation development. Water, in lakes, reservoirs, rivers and streams, is the greatest single factor in attracting and influencing recreation in the basin. Other factors include scenic beauty, climate, elevation, tree cover, available water supply, motor vehicle accessibility, and relationship to urban centers. Future recreation development will continue to be influenced by these factors.

RECREATION PLANNING PRINCIPLES AND OBJECTIVES

Planning for recreation facilities and projecting recreation uses in the Upper Feather River Basin must recognize the basin as a watershed and a timber producing area. These purposes are related and interdependent. All of the land in the basin contributes to this purpose; and all of the land has an appropriate recreation use in full compatibility with this purpose -- provided such use does not destroy the watershed, timber-producing ability of the land and thereby destroy the recreation resource. Planning for recreation must also recognize and not conflict with general, long-term objectives of promotion and protection of public health, safety, peace, morals, comfort, convenience and general welfare for the present and future inhabitants of the basin, the state and the nation.

Physical development programs, therefore, must be related to the prime purpose of the basin by varying intensities of use determined by land characteristics and the ability of the land to withstand the pressure of use. They must also be within the limits of what is desirable, safe and healthful for continued enjoyment of "outdoor" recreation. The following clearly points out the effects of excessive recreation use on public health, safety and property which the U.S. Forest Service learned from practical experience:

> Overcrowding of the developed areas and the resultant use of unimproved areas endanger the water supplies of nearby towns and cities; constitute a fire threat to valuable stands of timber, and a threat to streams and lakes. Spread of human disease and forest fires can result from these conditions. The potential damage to public health and public (and private) property could easily exceed the cost of adequate sanitation and care at public (or private) recreation areas. A single disastrous fire by one 'roadside camper' who couldn't find space in a developed area in the big timber country has cost $500,000 to suppress, and in addition caused damages to timber and soil, and watersheds running into millions of dollars.[1]

Sound management practices and programs conserving timber resources and achieving fish and wildlife enhancement add to the recreation attractiveness of the basin and set the limits on plans of development and on the "ultimate" potential for recreation use. Potential recreation development and use should be compatible with the following management objectives: (1) to obtain maximum production of water from the snowpack area; (2) to obtain maximum production of forest products for harvest on a sustained bases; and (3) to maintain or improve forage production for wildlife or livestock on lands unsuited for timber.[2]

From these concepts, defining the basic planning goals and objectives which are of foremost importance in the Upper Feather River Basin, certain general planning principles were developed:

- Recreation use and development plans must be related to the best management principles to assure preservation of natural beauty and recreation resources through controlled densities and open-space reservation; prevention and control of air and water pollution; prevention and control of fire; and prevention of soil erosion by relating land uses to land characteristics and use capabilities.

1. U. S. Forest Service, Operation Outdoors, p. 4-5, 1957.
2. U. S. Forest Service, Region 5, Handbook, Management Direction for the Westside Sierra Subregion (Westside Intermediate Zone), 1946, p. 26.

- Development of recreation facilities should be staged and based on an overall plan to meet adequately the anticipated demand, prevent overcrowding of facilities that are provided, and to discourage use of undeveloped areas lacking proper sanitary facilities and fire control.

- Water development programs in the upper basin should be planned, constructed, and administered to enhance the economy of the area with full recognition that recreation constitutes a major industry.

- Balanced development to satisfy projected future needs must be considered in the proposed uses for each area, especially those adjacent to proposed reservoirs. Best land use must control projected development in any single area, but the overall developmental plan should be so balanced as to enhance the attractiveness of the area to recreationists of many interests.

- Recreational areas should be planned to take advantage of the natural features of each watershed as well as those of the reservoir areas.

- Recognizing the economic impact and the demands which will be made upon local governments to provide services, developmental plans should provide for a balanced between private (either complete or "leasehold") and public ownership of recreation facilities available for public use to enhance the local tax base to enable local governments to finance the services they must provide.

- Public recreation facilities should be planned to contribute to repayment of costs.

CRITERIA FOR LOCATING RECREATION FACILITIES

Most existing recreation uses in the basin have developed as the result of a number of physical, economic and social factors. Examination of existing uses related to the planning goals, objectives and principles provided a "framework" for the preparation of criteria governing or influencing the development of specific types of recreation areas and facilities in the basin. These criteria are the basis for development standards which are applied in measuring potential recreation use, and in designing reservoir recreation areas. It should be noted, however, that these criteria do not preclude reasonable revisions in the final locations of specific uses. But in no case should recreation development be in violation of sound management practices. The following paragraphs include the general criteria used in locating specific types of recreation facilities.

Camping and Picnicking - Units should be a minimum of 100 feet apart in order to preserve the forest cover, provide privacy and a sense of being in the "great outdoors". Water system and sanitation facilities are required. Areas should be easily accessible to existing or future roads or trails. Terrain in site areas should not exceed 20 percent slope and a 10 percent slope is preferable. Area requirements should be based on provision of uncrowded, safe healthful conditions. Densities should be controlled to avoid overcrowding, either by doubling up at units or by persons camping in between units, to prevent damage to the ground cover, destruction of screening shrubs and young trees, excessive ground compaction, the menace of dust, and the use of sanitary facilities in excess of capacity. Site areas should be related to compatible recreation areas such as wildlife areas, primitive areas and, in some cases, organization camps. Location on rivers, streams and lakes is preferable, but not necessary in each case. They should also be related to "control" and service installations to facilitate operation, maintenance, and administration.

Organization Camps - A water system, sanitation facilities and easy access by present or future roads are required. Terrain in site areas should not exceed 20 percent slope, but relatively flat areas should be available for play and recreation activities. Locations on or within short distances of streams and lakes with opportunities for swimming and possible boating are preferable, but not necessary in each case. Organization camps should be separate from other types of facilities where conflicts in purpose and intensity of use may arise, but they should be easily accessible to forest areas and other areas of recreation attraction.

Resorts* - These facilities can serve as control points, and provide other commercial facilities such as restaurants, bars and amusements. Limited general retail facilities, groceries, sporting

* Includes hotels and motels.

goods, gasoline and oil, and other services may be either incorporated or located nearby. Location on a stream, river or lake is desirable but not mandatory. A potable water supply is essential, either from underground sources, spring, or distribution system, and sanitary disposal of waste is necessary. Site areas should have buildable slopes not exceeding 20 percent. Consideration should be given to other recreation facilities which would increase normal site areas such as golf courses, equestrian facilities and possible winter sports facilities. Adequate off-street parking should be provided to serve the needs of not only those people staying at the resort but also for the people who will seek the additional commercial facilities that may be provided. Easy accessibility to roads and major circulation routes are necessary. String location of resorts along roads or highways should be prevented to avoid traffic hazards and the destruction of the area's natural beauty. Resorts can be compatibly related to permanent and summer home areas, commercial areas, winter sports areas and, with proper design, to camp and picnic areas by providing service and goods to these areas. Resorts are desirable within urban areas provided suitable sites are available adjacent to compatible land uses.

Permanent and Summer Homes - Site areas not exceeding slopes of 35 percent can be utilized. (Slopes of less than 5 to 10 percent may have greater potential for other recreation uses). Sites should be adequate to maintain privacy and the feeling of openness. "Scatteration" should be avoided since this results in excessive and unreasonable costs in extending roads and services and complicates timber management programs. Location on a stream or lake is desirable but not necessary and should not be permitted at the expense of public use. A potable water supply is necessary, and disposal of waste by sanitary means is required. Septic tanks, chemical systems, small disposal plant or privies can be used (as permitted by Forest Service in the case of U. S. Forest Land, or county health department, in the case of private land). Summer homes should be related to resorts, commercial areas and recreation attractions and easily accessible to existing or future roads.

SITE DEVELOPMENT STANDARDS

Research in outdoor recreation use and practices, the recreation survey of the basin and the criteria for locating recreation facilities provided the basis for deriving site development standards.

The normal capacity of a "recreation unit" should be based on the average size of party. The average size of party using National Park and Forest Service outdoor recreation facilities is 2.3 persons; and for California State Parks the average size of party ranges from 3.7 to 4.3 persons.[1] The U. S. Forest Service considers a family group of five a desirable capacity per unit and uses that figure to calculate safe capacity of camp and picnic areas.[2]

The average capacity for four persons per recreation unit was adopted for this investigation and applied to all types of facilities as a reasonably conservative standard for safe, uncrowded use.

Experience and research demonstrate that there are minimum, maximum and optimum density standards that can be applied to development areas. For example, camp and picnic units (or family units) should be spaced no closer than 100 feet apart, or 5 per acre in staggered arrangement in the forest areas and in more intensive areas no closer than 50 feet apart or 10 per acre. Practical per acre site development density standards based on average conditions are shown in Table 9.

The site density standards must be applied in relation to a desirable pattern of development and overall use density considerations. It is generally recognized and accepted that scattered

1. Kenneth Decker, Natural Resources of Northwestern California (Preliminary Report Appendix), June, 1957, p. 20.
2. U. S. Forest Service, Operation Outdoors, 1957, p. 11.

development is harmful and undesirable from the standpoint of aesthetics, economics in construction, maintenance, and administration and contrary to good forest and land management conservation principles. Cluster standards were developed based on economy derived in construction and administration to prevent both scatteration and overcrowding. These standards are shown in Table 10.

The minimum cluster is considered to be adequate for economical development, while the maximum cluster is a reasonable limit to avoid overcrowding and maintain the natural areas. In actual development, design considerations would govern the exact cluster standard or modification that would be used. The rugged topography and forest cover will provide natural barriers helping to prevent sprawling, congested or over-intensified development.

9. SITE DEVELOPMENT PER ACRE DENSITY STANDARDS BY TYPE OF RECREATION FACILITY AT ULTIMATE DEVELOPMENT, YEAR 2050.

Recreation Use	Units per net Developed acre	Capacity People per net Developed acre
Camp and Picnic	5	20
Camp and Picnic - Genesee Park	10	40
Organization Camp	1.25	5
Resort, hotel, motel	2.5	10
Summer home	1.0	4

10. MAXIMUM AND MINIMUM RECREATION UNIT STANDARDS (CLUSTERS) BY TYPE OF RECREATION FACILITY AT ULTIMATE DEVELOPMENT, YEAR 2050.

	Units per Cluster		Site Area (acres) per Cluster	
Recreation Use	Minimum	Maximum	Minimum	Maximum
Camp and Picnic	25	50	5	10
Organization Camp	25	100	20	125
Resort, hotel, motel	6	100	2.4	40
Summer Home	1	*	1	*

* Summer home clusters should be large enough to justify the provision of services, and number and size of areas permitted should be based on the ability of the land to support them and maintain the "outdoor" character.

RECREATION USE STANDARDS

Potential recreation use in terms of visitor-days requires determination of the number of days each different type of facility would be used in relation to its normal capacity (the total number of people that can be accommodated at one time).

In the preliminary recreation studies for the Department of Water Resources, prior to the actual field survey, potential use was determined by multiplying a length of season (the total number of days a recreation facility would be available for use) by its normal capacity to obtain capacity visitor-days use. This was then multiplied by an estimated percentage of capacity use (50 percent) to give a conservative probable annual visitor-days use.

Any length of season not greater than 365 days can be applied to estimate annual visitor-days use provided it is adjusted by a reasonable percentage of capacity use. During the course of the survey of the basin, interviews of resort owners indicated that lengths of season in the basin are affected by many immeasurable factors, but are primarily controlled by:

- o Weather - the number of days suitable for outdoor travel and recreation use.
- o Administrative Policies - the time and length of hunting and fishing seasons; the vacation periods permitting recreation use; and the school year.

In the case of privately owned facilities, a resort operator, for example, may make his resort available for use only during the period of time that his seasonal liquor license is valid. The length of season for organization camps is controlled by administrative policy which requires advance registration so that efficient operation and high percentage of use is achieved, usually during a short season. The length of season for summer homes is determined to some extent by the school vacation period and "long week-ends" and holidays. Many retired people live in "summer" homes the full year, and this practice is expected to become more prevalent in the future.

Average lengths of season and percentages of capacity use for the Upper Feather River Basin in 1956 obtained from the survey of existing recreation areas and facilities in the basin are :

Recreation Use	Average length of season (days)	Percent of Capacity Use
Camping and picnicking	175.4	66.1
Organization camps	74.8	95.1
Resorts, hotels, motels	230.0	57.1
Summer homes	90.2	46.1
All facilities	91.2	60.3

Camping and picnicking provide perhaps the most realistic measure of the "outdoor" length of season. These public facilities are usually available whenever people desire to use them, unless the intensity of use becomes so great as to impair sanitation and safety conditions requiring closure. Many resorts, hotels and motels presently operate at full capacity from one to three months during the summer season. Several of the hotels and motels stay open all year but operate on a limited basis during the winter months. During the 175-day camping and picnicking season these "indoor" facilities operate at a much higher percent use than shown above.

Analysis and evaluation of available U. S. Forest Service recreation data and research applicable to the basin resulted in the adoption of a use factor[1] which can be applied to measure the overall ultimate recreation visitor-days use. The use factor combines the annual length of season and the percentage of capacity use into one factor. It is a measure of the intensity of annual use and averages the effects of peak and low use periods. Intensities of visitor-day use compiled from available records and survey are contained in Table A-6 in the Appendix. Examination of these data indicate certain pressures of recreation use which

1. John Zivnuska and Ann Shiedler, "A Projection of the Recreation Use of Public Forest Areas In California to 1965". Forest Science, Vol. 3, No. 3, September, 1957.

influence decisions on the provision of future use.

The Forest Service states that "...the capacity of camp and picnic areas should be calculated on the basis of five persons per family unit and that the safe capacity should be 85 percent of maximum capacity. Use of such volume can be accommodated without damage to the area and will enable people to enjoy the forest environment. On this basis one family sized unit is needed to accommodate 425 man days (visitor-days) use in a 100-day season."[1] In effect, this means a use factor of 85 can be considered as a safe, desirable, healthful, uncrowded intensity of use for camping and picnicking facilities.[2]

Safe use intensities of summer homes and organization camps can be best controlled by the density of development. The available trends show that the intensity of use for summer homes has been steadily increasing in California and this trend is expected to continue with the improvement of social and economic conditions. The intensity of use of organized camps is also expected to increase ultimately. Many resort, hotel and motel operators in the Upper Basin complain that their facilities are not presently used to an optimum intensity. It is expected that with the development of planned reservoirs and winter sports areas the intensity of use will be much higher over a longer recreation season.

Determination of future winter sports use intensities presents a different problem since existing intensities are relatively low and areas for winter sports throughout California are in the process of rapid development. The facilities under construction for the 1960 Olympic Games at Squaw Valley are expected to stimulate winter sports development and use of other nearby

1. U. S. Forest Service, Operation Outdoors. 1957, p. 13.
2. The use factor of 85 was used as an index to determine percentages of adequacy or inadequacy of existing camping and picnicking facilities in Part II.

areas such as the Eureka Bowl area near Johnsville. Trends do not adequately reflect the above anticipated conditions so that estimates of future winter sports use intensities in the basin may appear to be high. Safe winter sports use will depend primarily on accessibility, adequate snow removal, provision of appropriate off-highway parking areas, shelter facilities and safety equipment, and proper enforcement of safety measures.

Table 11 includes the recreation use factors (recreation use intensities) and comparable lengths of season and percentages of capacity use by type of recreation facility which were developed and applied in obtaining the ultimate recreation use of the basin. The "probable" figures correspond to the trends tempered by considerations of safe, uncrowded use. In addition, they are considered to be conservative and therefore reasonable figures for such long range projections as are used in this study. The "minimum" figures are comparable to those used in previous studies for the Department of Water Resources. They are considered to be ultra-conservative.

11. USE FACTORS, LENGTHS OF SEASON AND PERCENTAGES OF CAPACITY USE BY TYPE OF RECREATION FACILITY AT ULTIMATE DEVELOPMENT, YEAR 2050.

Recreation Use	Use Factor		Length of	Percent of Capacity Use	
	Probable	Minimum	Season	Probable	Minimum.
Camp & Picnic	85	57.5	115	73.9	50.0
Organization Camp	70	57.5	115	60.9	50.0
Resort, hotel, motel	90	57.5	115	78.3	50.0
Summer Home	45	22.5	115	39.1	19.6
Winter Sport	40	25.0	80	50.0	31.3

PART V. RECREATION USE OF RESERVOIR STUDY AREAS AND THE MIDDLE FORK OF THE FEATHER RIVER

Past trends show that recreation use is affected by water development to such an extent that potential use of the study areas without additional water development would appear very small indeed. Water development would create much greater use by virtue of the vastly increased potential for use and the enhancement of the recreation attraction.

With the assistance of the State Department of Fish and Game, estimates of present visitor-day use of each study area were developed as the beginning point for projections of potential use. Present recreation use of these areas is small and almost entirely limited to hunting and fishing with practically no development of recreation facilities, as shown in Table 12. Most of the present use is in the "other forest areas" classification.

12. ESTIMATED PRESENT RECREATION USE IN RESERVOIR AREAS IN UPPER FEATHER RIVER BASIN, 1956.

Reservoir Area	Hunting	Fishing	Total
Authorized Projects:			
Grizzly Valley	700	200	900
Antelope Valley	500	500	1,000
Abbey Bridge	500	100	600
Dixie Refuge	500	100	600
Frenchman	1,000	100	1,100
Reservoirs under study			
Squaw Queen	600	300	900
Sheep Camp	500	100	600
Turntable	100	600	700
Meadow Valley	300	400	700
Swayne	400	700	1,100
Humbug	700	1,300	2,000
Genesee Valley	100	500	600
Total	5,900	4,900	10,800
Richvale Projects:			
Nelson Point	200	800	1,000
Clio	500	1,500	2,000

Economic evaluation of recreation development requires that benefits be based on visitor-day use of the developable facilities for which costs are determined. Use of developed facilities historically accounts for less than half of the total visitor-days, and the estimates of potential use of the study areas can be considered conservative in terms of the total use, which includes "other forest areas" and "highway users" in addition to use of developable facilities.

FUTURE RECREATION USE WITHOUT WATER DEVELOPMENT

Estimates of potential visitor-day use of each study area without additional water development are required to provide a reasonable base for determining the net increase in development and use which would result from reservoir construction. It is anticipated that without the construction of the dams and reservoirs the use of the study areas by hunters and fishermen would increase each year provided the areas were properly managed to maintain fish and wildlife. Along with this increase, there is the likelihood that there would be increased development and use for other recreational activities. Liberal estimates of potential visitor-day use without additional water development were obtained by using the broad standards developed in the Northeastern Counties Investigation (Bulletin No. 58, Appendix A).

Ultimate recreation use without additional water development is expected to reach a minimum of 222,300 annual visitor-day use by 2050 for the five authorized reservoir areas and most likely a probable annual use of 349,177 visitor-days. The reservoir areas under study, excluding Swayne and Humbug, are expected to have an ultimate minimum and probable visitor-day annual use of 550,024 and 862,394, respectively. Total ultimate recreation use for all project areas, including authorized, studied and Swayne and Humbug, would be a minimum of 945,006 and a probable 1,481,276 visitor-day annual use by 2050. The proposed Richvale project areas of Nelson Point and Clio would have a minimum and probable 220,017 and 345,645 total visitor-day annual use. Table 13 shows the minimum ultimate recreation visitor-day annual use for each reservoir area by type of recreation facility estimated using the preliminary use standards developed in Appendix A of Bulletin 59. Table 14 shows the probable ultimate use estimated, based on the updated use standards developed in Part IV.

13. ULTIMATE MINIMUM RECREATION VISITOR-DAYS ANNUAL USE OF RESERVOIR AREAS WITHOUT ADDITIONAL WATER DEVELOPMENT BY RECREATION FACILITY, 2050.

Reservoir Area	Camp & Picnic	Organization Camps	Resorts	Summer Homes	Total
Authorized Projects:					
Grizzly Valley	54,280	865	4,320	12,060	71,525
Antelope Valley	34,040	446	3,024	7,560	45,070
Abbey Bridge	30,820	430	2,160	6,930	40,340
Dixie Refuge	23,184	313	2,073	5,220	30,790
Frenchman	26,220	345	2,160	5,850	34,575
Sub-total(1)	168,554	2,399	13,737	37,620	222,300
Reservoirs under study					
Squaw Queen	111,320	1,553	9,936	24,840	147,649
Sheep Camp	22,080	690	1,080	1,710	25,560
Turntable	66,240	863	5,940	14,760	87,803
Meadow Valley	112,240	2,070	10,004	25,200	149,514
Genesee Valley Park	105,340	1,380	9,288	23,490	139,498
Sub-total (2)	417,220	6,556	36,248	90,000	550,024
Swayne	81,926	1,035	9,384	18,324	110,669
Humbug	42,504	5,175	4,830	9,504	62,013
Sub-total (3)	124,430	6,210	14,214	27,828	172,682
Richvale Projects:					
Nelson Point	85,468	1,208	9,798	19,116	115,590
Clio	77,280	1,035	8,832	17,280	104,427
Sub-total (4)	162,748	2,243	18,630	36,396	220,017
Total - (1) & (2)	585,764	8,955	49,985	127,620	772,324
Total - (1), (2) & (3)	710,194	15,165	64,199	155,448	945,006

14. ULTIMATE PROBABLE RECREATION VISITOR-DAYS ANNUAL USE OF RESERVOIR AREAS WITHOUT ADDITIONAL WATER DEVELOPMENT BY RECREATION FACILITY, 2050.

Reservoir Area	Camp & Picnic	Organization Camps	Resorts	Summer Homes	Total
Authorized Projects:					
Grizzly Valley	80,334	1,053	6,782	24,120	112,289
Antelope Valley	50,379	547	4,748	15,120	70,794
Abbey Bridge	45,614	526	3,391	13,860	63,391
Dixie Refuge	34,312	378	3,255	10,440	48,385
Frenchman	38,806	421	3,391	11,700	54,318
Sub-total (1)	249,445	2,925	21,567	75,240	349,177
Reservoirs under study					
Squaw Queen	164,754	1,895	15,600	49,680	231,929
Sheep Camp	32,678	842	1,696	3,420	38,636
Turntable	98,035	1,053	9,326	29,520	137,934
Meadow Valley	166,115	2,525	15,706	50,400	234,746
Genesee Valley Park	155,903	1,684	14,582	46,980	219,149
Sub-total (2)	617,485	7,999	56,910	180,000	862,394
Swayne	121,250	1,263	14,733	36,648	173,894
Humbug	62,906	6,314	7,583	19,008	95,811
Sub-total (3)	184,156	7,577	22,316	55,656	269,705
Richvale Projects:					
Nelson Point	126,493	1,474	15,383	38,232	181,582
Clio	114,374	1,263	13,866	34,560	164,063
Sub-total (4)	240,867	2,737	29,249	72,792	345,645
Total - (1) & (2)	866,930	10,924	78,477	255,240	1,311,571
Total - (1), (2) & (3)	1,051,086	18,501	100,793	310,896	1,480,276

RECREATION USE OF RESERVOIR AREAS

Site Utilization studies were prepared to determine potential visitor-day use of each of the fourteen reservoirs and the Middle Fork of the Feather River. These studies were based on field survey, available topographic maps and both aerial and ground photographs. Suitable recreation areas were delineated using the criteria for locating facilities evaluated against the recreation planning principles and objectives developed in Part IV. Site development standards were applied to the developable acreages to determine the number of areas and units for camp and picnic facilities, organization camps, resorts and summer homes that could be developed. Recreation use standards were then applied to determine potential safe visitor-day use of these facilities.

A description and evaluation of each reservoir area, currently under study, and illustrative site development plans are presented in subsequent pages. Included in the Appendix is the description and evaluation of the authorized Grizzly Valley, Antelope Valley, Abbey Bridge, Dixie Refuge, and Frenchman reservoir areas. Illustrative site plans and a summary of the evaluation of recreation benefits and costs of these authorized projects were presented in Appendix A of Department of Water Resources Bulletin No. 59, February 1957. Limitations on the size of that report prevented full description and evaluation at that time. Only summaries of these evaluations are contained in the sections and tables that follow.

Reservoir areas presently under investigation include Squaw Queen, Sheep Camp, Turntable, Meadow Valley, Genesee Valley Park, Swayne and Humbug reservoirs. Also included are the Richvale Irrigation District reservoir areas of Nelson Point and Clio.

Authorized projects and areas presently under investigation are discussed below. The findings for the fourteen study areas are summarized in tables 28 through 31 at the end of this section. Illustrative site development plans for areas under study are shown on Plates II through IX.

Authorized Projects

A total of 4,200 visitor-days use by hunters and fishermen was estimated for the five authorized reservoir areas in 1956. At ultimate development (2020-2050) probable use would be almost 349,200 annual visitor-days without reservoir construction. Recreation development of these projects will increase their probable use almost four time to more than 1,651,900 annual visitor-days. A net increase of 1,302,700 annual visitor-days will result from water development.

Reservoirs Under Study

o Squaw Queen Reservoir Area:[1]

The location of Squaw Queen Reservoir area is in the northeast portion of the Upper Feather River Basin at the confluence of Squaw Queen and Last Chance Creeks. It is almost equidistant from the authorized reservoirs of Antelope Valley in the north, Abbey Bridge in the south and the Genesee Valley Park area on the west. Each of these areas is from three to four miles from Squaw Queen "as the crow flies". The reservoir location can best be reached from U.S. Highway 40 Alternate from Portola and Beckwourth. It can also be reached from Indian Valley and Taylorsville by a 20 mile trip over county roads.

The area lies at an elevation of 5,300 feet and has a variety of topographic conditions. There are areas of relatively smooth terrain surrounded by slopes ranging from 15 to 30 percent. The reservoir area is shaped like a block "C". The southeast neck of the reservoir extends into Squaw Valley which has a flat floor averaging one-half mile in width with gradually increasing slopes on either side. While this valley, itself, is dry with little or no cover, the major northern portion of the area is well covered with second growth timber.

1. See Plate II, p. 31

While power production is the primary purpose of the reservoir, it will also provide water for irrigation in Indian Valley. The normal pool elevation of 5,471 feet will drop very gradually during the summer recreation season but this drawdown will have little adverse affect on recreation use. At normal pool elevation the water surface area will cover 2,700 acres.

The reservoir will have several unusual features, notably an extremely irregular shoreline with numerous inlets and peninsulas. The north-south axis of the lake extends about six miles. The southeast arm of the lake is a little over four miles long. The width of the reservoir varies from 500 to 3,000 feet, although the existence of several inlets causes the effective width at these locations tobe in the neighborhood of a mile.

The relationship of Squaw Queen Reservoir to three other reservoir recreation areas will influence its development. Antelope Valley, Abbey Bridge, Genesee Park and Dixie Refuge reservoirs are all within a few miles drive of Squaw Queen. It can be assumed that the cumulative effect on recreation demand found in an area containing three reservoirs and one park will be felt in all four areas, with more demand at Squaw Queen because of its natural characteristics and location in the center of the area.

Practically all of the 35 miles of shoreline is usable, permitting maximum development of balanced recreation densities. The construction of a perimeter road completely around the reservoir is planned to provide access to any point. The gradual, well-covered slopes of the north-south arm of the reservoir permit extensive and varied recreational uses. The steeper slopes immediately overlooking the shore are suitable for summer homes. The many inlets of the lake serve as ideal boat harbors and protected swimming areas. The southeast arm of the reservoir reaching into Squaw Valley has broad and gradually sloping sandy beach areas, although it lacks natural cover. The narrow width of the reservoir in several places limits intensive boating activities to particular areas of the reservoir such as the lower southeasterly portion.

Camping and picnicking sites are located about the shoreline where the slope, presence of natural cover and access by road are most suitable for this use. Such development is possible along most of the lakeshore. The lake extension into Squaw Valley, which lacks natural cover, is best suited as open beach area for swimming and boating activities. Organizational camping is provided both at sheltered inlets on the shoreline and upon the covered slopes some distance from the shoreline. Resorts, or lodge and commercial areas, are located along the shoreline related to camping and picnicking and summer home development. Summer homes are located on the slopes back from the lakefront, affording these sites a view of the lake and surrounding terrain.

15. SQUAW QUEEN RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050.

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	380	1,900	7,600	874,000	437,000	646,760
Organizational Camps	490	613	2,450	281,750	140,875	171,870
Resort-Commercial	255	638	2,550	293,250	146,625	230,200
Summer Homes	2,900	2,900	11,600	522,000	261,000	522,000
Total	4,025	6,050	24,200	1,971,000	985,500	1,570,830

o Sheep Camp Reservoir Area:[1]

Sheep Camp Reservoir area is located in the southeastern portion of the Upper Basin on the western edge of Sierra Valley. The reservoir site may be reached by county road from State Highway 89 via Calpine or Blairsden and from U.S. Highway 40 Alternate via Beckwourth. The reservoir is two miles northwest of Calpine; nine miles south of Beckwourth and Portola. The area lies at an elevation of 4,900 feet, and is separated from Sierra Valley by

1. See Plate III.

a hilly ridge with two connecting openings. The reservoir will be created by obstructing one of these canyons with a dam and the other with a spillway, resulting in an irregular but generally oblong water surface. It is approximately three miles long ranging from one mile to one-half mile in width and tapering at both ends. At the southwestern end a small inlet exists as a narrow-necked extension of the lake.

The main purpose for the reservoir is irrigation for Sierra Valley. The normal pool elevation of 4,997 feet will drop gradually during the summer recreation season; however, the drop will not significantly affect recreation use. The water surface area will cover 1,630 acres at normal pool elevation.

The development of recreation areas on the lakeshore is restricted to the northwestern shore and portions of the eastern and southern shores. Although there is sufficient tree cover about the area, the terrain is rough in several locations causing developmental limitations. Installation of a perimeter road adjacent to the lakeshore is planned to permit access to most any point on the lake. A ridge behind the northwest shore separates the reservoir from another adjacent valley-like area. This creates two distinct yet complementary recreational environments. The area northwest of the ridge contains fairly level ground, two running streams, and sufficient cover to permit favorable development for recreational use. This area is then connected by road to the reservoir and its lakeshore recreational development. The result is a well balanced recreational development of the entire reservoir area.

The recreational development of Sheep Camp Reservoir will be influenced by its relative location to Calpine and the State highway system. Calpine is a growing summer home and resort area only 2 miles from the dam site on State Highway 89, which is well travelled by visitors to the area.

The northeastern shore and a portion of the southern shore are planned for camping and picnicking development. Organization camps have been located on the northern end and a portion of the eastern shore of the reservoir as well as in the valley north of the ridge. The upper portion of the eastern shore has been reserved for beach purposes. Lodge and commercial areas have been located about the reservoir and adjacent valley in relation to the other recreational development. Some summer homes have been placed on the slopes at the northern end of the reservoir and in the adjacent valley.

16. SHEEP CAMP RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050.

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	190	950	3,800	437,000	218,500	323,380
Organizational Camps	205	256	1,024	117,760	58,500	71,830
Resort-Commercial	120	300	1,200	138,000	69,000	108,330
Summer Homes	1,090	1,090	4,360	196,200	98,100	196,200
Total	1,605	2,596	10,384	888,960	444,480	699,740

o Turntable Reservoir Area:[1]

This reservoir area is at an elevation of 3,780 feet, located on the Middle Fork of the Feather River in the south-central portion of the basin. The dam site would be about twelve miles downstream from Sloat on the Middle Fork of the Feather River. The area is eight miles southeast of Quincy and twenty miles northeast of La Porte on the Quincy La Porte county road.

The reservoir, constructed for power production with a normal pool elevation of 4,024 feet, would have a water surface area of 650 acres. The reservoir will be relatively narrow and will exceed six miles in length. Near the dam site water will be backed up into two canyons which are perpendicular to the river. The largest of these, formed by Nelson Creek, is two miles long and the smaller one less than one-half mile long. The reservoir will have a width of 1,100 feet near the dam site. The power releases, lowering the normal pool elevation,

1. See Plat IV.

after the recreation season will have no appreciable affect on recreation use.

The reservoir area is characterized by very rugged topography with deep canyons rising straight from the river's edge. The steep slopes on both sides of the reservoir for the most part prohibit the development of roads. Many sites along the slopes suitable for camping and picnicking can be reached only by foot or by boat. This rugged terrain suggests a recreation development plan which will retain much of the area in its original state giving the site a "wilderness" character. The rugged, scenic quality of this area with development designed to preserve more fully its original character will draw many recreationists seeking this "secluded" environment.

Camp and picnic sites are located along the slopes and banks of the reservoir where the terrain is suitable. A system of foot trails and boat facilities provide access to those recreation areas otherwise inaccessible. Boat launching sites and lodge and commercial facilities are provided at locations which can be reached by roads. Several large areas close to the reservoir are planned for summer homes as well as public recreation. Summer home sites accessible by existing roads are also located at suitable higher elevations overlooking the lake.

17. TURNTABLE RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050.

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	183	915	3,660	420,900	210,450	311,470
Organizational Camps	-	-	-	-	-	-
Resort-Commercial	147	367.5	1,470	169,050	84,525	132,700
Summer Homes	1,204	1,204	4,816	216,720	108,360	216,720
Total	1,534	2,486.5	9,946	806,670	403,335	660,890

o Meadow Valley Reservoir Area:[1]

The Meadow Valley Reservoir area is at an elevation of 3,480 feet situated in the center of the Upper Feather River Basin, approximately seven miles northeast of Bucks Lake. The

1. See Plate V.

dam site is located three miles west of Quincy on Spanish Creek. It is easily accessible from Quincy on U.S. Highway 40 Alternate, via Bucks Lake Road. The area about the reservoir is rich in tree cover and scenic beauty. The trees are mainly second growth temper. The scenery is typical of Sierra forests and woodlands with a mixture of rock formations. Immediately west of this location, Spanish Peak rises to a height of 7,000 feet forming an impressive backdrop.

The "square" shaped reservoir has a normal pool elevation of 3,898 feet. At this elevation the surface area of the reservoir will be 5,750 acres, or nine square miles. Its maximum length and width will be four miles and three miles, respectively. There will be a number of islands, the largest of which will be over a mile long and almost one-half mile wide. Its location, size, shape and natural features make this reservoir area one of the most promising sites in the entire basin for recreation development.

The primary purpose of this reservoir is production of hydroelectric power; irrigation, streamflow maintenance and domestic water supply are secondary. Operation of this reservoir as water storage for power production will not affect appreciably recreation use and development.

The outstanding characteristic of the reservoir area is the variety of topography which creates a varied recreation environment. Bluffs and abruptly descending slopes at the northeast and west shoreline restrict access and development, forcing preservation of these areas for scenic purposes. Pockets of usable, less steep land separated by the rugged terrain surround the reservoir in sufficient size and quantity for excellent well-balanced recreation development.

Recreation development of Meadow Valley Reservoir area is influenced by its location to other recreation areas and urban development. Bucks Lake, with long established balanced recreational development, is close by to the southwest. Snake Lake and Silver Lake, both good fishing lakes, are within hiking distance of the reservoir. Spanish Peak, which slopes directly to the shore of the reservoir, has potential for winter sports. Most important is Quincy, the county seat of Plumas County and a growing urban community, which is situated just below the dam site. Finally, the reservoir area is situated on the only direct route between Quincy and Bucks Lake.

The development plan for Meadow Valley Reservoir presents a balance of public and private recreation use. The ruggedness of the terrain requires that the development of the shoreline be reserved for public use, and public camp and picnic sites are located along the shoreline where terrain and access permit. Organizational camps are proposed along the southern shore; and, because of greater area requirements for this type of development and for balanced use, some organizational camps have been located a short distance from the shoreline in the isolated northeastern portion of the reservoir.

Resorts which include commercial and boating facilities are suitably located about the reservoir in relationship to the other kinds of recreational development they will serve. Summer homes are located on the slopes away from the shoreline thereby affording a view of the lake and the surrounding terrain, but with easy access by road to the public lakeshore and resort areas. The main island in the reservoir is proposed for resort, camp and picnic development.

18. MEADOW VALLEY RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050.

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	350	1,750	7,000	805,000	402,500	595,700
Organizational Camps	515	644	2,576	296,240	148,120	180,710
Resort-Commercial	185	462.5	1,850	212,750	106,375	167,010
Summer Homes	2,700	2,700	10,800	486,000	243,000	486,000
Total	3,750	5,556.5	22,226	1,799,990	899,995	1,429,420

o Genesee Valley Park Area:[1]

Genesee Valley, at an elevation of 3,670 feet, is located in the central portion of the basin approximately eight miles southeast of Taylorsville. The picturesque valley is long and flat, bordered by steep slopes rising sharply from the valley floor. Two smaller valleys extend laterally north and south from about the middle of Genesee Valley. Some tree cover is scattered in various locations on the valley floor.

This area was originally investigated as the site for a large reservoir, but additional engineering studies proved the infeasibility of the large dam site. The decision to locate the re-regulating reservoir for Squaw Queen Reservoir at the upper end of Genesee Valley, based both on engineering factors and the enhancement of the recreation area, led to further recreation and economic studies to judge its park capabilities.

The reservoir will be over two miles in length and about one-half mile wide at its widest point. The normal pool will be at 3,720 feet elevation and will cover an area of 675 acres. There will be virtually no water level fluctuation so that recreation use will not be affected by drawdown, and water will be constantly released to maintain full stream-flow of Indian Creek. The creek will be a recreation attraction running the length of the valley floor.

Most of the valley floor is open meadow and provision for some tree cover must be made in some areas. The walls of the valley are steep and for the most part not developable but they provide great scenic richness in their natural state. A few areas have developable terrain ranging from ten percent to twenty-five percent slope. These areas are suitable for resorts or lodges but not for campsites. The entrance to the valley from Taylorsville is a narrow canyon which opens into the meadow, and the upper end of the valley is defined

1. See Plate VI.

by the proposed dam, reservoir and valley walls. The enclosed space immediately west of the dam is ideal as an entertainment area.

Genesee Valley will receive recreationists and highway visitors because of its location, and the reservoir and park would be developed to accommodate them. The county road passing through Genesee Valley serves as a route to Squaw Queen, Antelope, Grizzly and Abbey Bridge reservoirs. In fact, Genesee Valley is the western gateway to the recreation areas in the northeastern portion of the Upper Basin, and is only 16 miles from the Indian Creek Junction of the U.S. Highway 40 Alternate and State Highway 89.

Since this area is proposed as a public park, development should be for public recreation use with lodge-commercial facilities included to support the public areas and facilities. Administrative and maintenance stations are placed at either end of the road running through the valley. Two more such stations are placed on control roads entering the valley from the southeast and the south. Camping and picnicking grounds are developed at those sites in the valley where tree cover exists. More sites can be developed as adequate cover is provided. All development is kept some distance from the creek so as to keep its banks open for maximum use. Camping sites connected by riding and hiking trails are planned for the two valleys joining Genesee. The extension of these trails up the surrounding slopes would allow the development of camp sites and observation points on the summits overlooking the valley. Both sides of the reservoir have sandy beaches for swimming and water activities, and picnic grounds have been provided to serve these areas.

Lodge and commercial facilities have been located at appropriate spots to serve the other recreation activities. One has been suggested on the south shore of the reservoir, another below the dam site, and several along the slopes of the valley. In keeping with park concepts, facilities not found at the other reservoir projects are included here. The enclosed space below the dam site has been planned for an ampitheater and music area with surrounding picnic grounds, other facilities for entertainment, and a park administration center. The small valley along Hosselkus Creek entering Genesee from the north is the location for a nine-hole golf course associated with the lodge.

19. GENESEE VALLEY PARK AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	280	2,800	11,200	1,288,000	644,000	953,120
Resort-Commercial	140	350	1,400	161,000	80,500	126,390
Total	420	3,150	12,600	1,449,000	724,500	1,079,510

o Swayne Reservoir Area:[1]

Swayne Reservoir area is located in the southwest portion of the Upper Feather River Basin, about ten air-miles northeast of the proposed Oroville Dam. The dam site, at an elevation of 1,930 feet, is on French Creek approximately three miles upstream from its junction with the North Fork of the Feather River which will be inundated by Oroville Reservoir at this point. The reservoir site is on the Quincy-Oroville Road, four and one-half miles northwest of the Brush Creek Ranger Station, 21 miles northeast of Oroville and 22 and 38 miles southeast of BucksLake and Quincy, respectively. The site is also accessible by forest service roads from Pulga in the North Fork Canyon on U.S. Highway 40 Alternate.

This reservoir will have an irregular shape, meandering through the canyons back of the dam. From the dam site to the farthest tip of the reservoir by boat is over four miles. The reservoir is approximately three-fourths of a mile across at its widest point near the dam site. The terrain about the reservoir is rugged and rises rapidly from the shoreline. There is a variety of tree cover in the area including both evergreen and some deciduous trees. The ruggedness

1. See Plate VII.

of the terrain limits the availability of usable land and disperses and separates these developable areas with large open space areas so that uncrowded recreation use is enforced by the topography.

Water storage for power production is the prime purpose for the construction of Swayne Reservoir. The normal pool elevation of 2,368 feet will cover an area of 2,550 acres. The tentative operation schedule indicates the draw-down will have little or no adverse affect on recreation use and development.

Of all the proposed reservoirs in the Upper Feather River Basin, excluding Oroville, Swayne is the closest reservoir to a moderately large center of population, the City of Oroville. Swayne will become a part of the Oroville Reservoir recreational complex, and demand for recreational development at Swayne will increase because of this relationship.

Recreational development is located about the reservoir area in pockets of suitable land, as permitted by the rugged terrain. Public camp and picnic sites and organizational camp areas are suggested near the shoreline. Other organizational camps and most summer home sites are located on slopes overlooking portions of the lake. Resort and commercial developments are proposed in appropriate relationship to the other recreational developments.

20. SWAYNE RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050.

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	165	825	3,300	379,500	189,750	280,830
Organizational Camps	75	94	375	43,125	21,563	26,380
Resort-Commercial	72	180	720	82,800	41,400	65,000
Summer Homes	730	730	2,920	131,400	65,700	131,400
Total	1,042	1,829	7,315	636,825	318,413	503,610

o Humbug Reservoir Area:[1]

Humbug Reservoir is located on Yellow Creek in the western portion of the Upper Basin some 15 miles south of Chester, eight miles southeast of Prattville on Lake Almanor and ten miles north of Belden in the Feather River North Fork canyon. The reservoir site is connected to all of these locations by roads. The area is presently a wide, flat valley at an elevation of 4,240 feet, surrounded by low, rolling hills. The valley floor is covered with grasses and a few trees. The surrounding hills, however, are covered with dense growths of timber.

The pear-shaped reservoir will be approximately 3.5 miles long and one mile across at its greatest width, tapering to less than 700 feet at the dam site. The surrounding terrain slopes gradually up from the lakeshore, except for an area on the lower east side of the reservoir. The shoreline is also well forested, except for a section on the northwestern tip of the reservoir where a forest fire has destroyed much of the tree cover.

Humbug reservoir, designed for power production, will be comparatively shallow due to the topographic conditions. For these reasons the extent and elevation of the lake surface may be expected to drop during dry years. Tentative operation schedules, however, indicate that variation from normal pool elevation of 4,357 feet, covering an area of 1,790 acres, will not be so great under normal, average conditions as to prevent recreation development.

The surrounding gentle sloping terrain, particularly to the north and west, provide ample space for various kinds of recreation development. The existence of sufficient tree cover around the reservoir permits a balanced and integrated recreation development. Development will be influenced by the area's orientation to the Lake Almanor area, twelve miles to the northeast, with its well established and growing recreation community of Chester. The attraction of visitors to the Lake Almanor area can be expected to increase the use of Humbug for Recreation.

1. See Plate VIII.

Camp and picnic sites are located mainly around the northern end of the reservoir and near the dam site at the southern end. Organizational camps are indicated near the middle on both sides of the lake where the slope of the terrain, access to the lake, and cover are best suited for this use. Lodge and commercial developments are located in several spots around the lakeshore in relation to other recreational development. Summer homes are provided on the slopes overlooking the reservoir.

21. HUMBUG RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	140	700	2,800	322,000	161,000	238,280
Organizational Camps	120	150	600	69,000	34,500	42,090
Resort-Commercial	85	212.5	850	97,750	48,875	76,730
Summer Homes	960	960	3,840	172,800	86,400	172,800
Total	1,305	2,022.5	8,090	661,550	330,775	529,900

o Nelson Point Reservoir Area:[1]

Nelson Point Reservoir area, at an elevation of 3,680 feet, is located on the Middle Fork of the Feather River, with the dam site twelve miles downstream from Sloat. This reservoir, proposed by the Richvale Irrigation District, has the same location as Turntable Reservoir with the dam site located about two and one-half miles farther downstream than the Turntable site.

The reservoir would be constructed for power purposes. The normal pool elevation of 4,030 feet will have a water surface area of 1,140 acres, almost twice the surface area of Turntable Reservoir. The tentative operation schedule indicates that the drawdown will have little appreciable affect on recreation use and development.

Nelson Point and Turntable Reservoirs are identical in the development plan upstream from Turntable. Nelson Point has an additional 5 miles of shoreline and a greater water surface area, and therefore possibilities of added recreation use and development. The area between

1. See Plate IV.

the two dam sites is extremely rugged. Slopes to the waterline are precipitous except for a few isolated locations. Some additional public camping and picnicking development is provided at these locations served by trails and a dam maintenance road. Most of the additional development is located overlooking the reservoir on the canyon rims.

22. NELSON POINT RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	237	1,185	4,740	545,100	272,550	403,370
Organizational Camps	-	-	-	-	-	-
Resort-Commercial	250	625	2,500	287,500	143,750	225,690
Summer Homes	1,279	1,279	5,116	230,220	115,110	230,220
Total	1,766	3,089	12,356	1,062,820	531,410	859,280

o Clio Reservoir Area:[1]

Clio Reservoir area, also a proposed Richvale Irrigation District project, is located in the southeast portion of the Upper Feather River Basin at Mohawk Valley, three and one-half miles southeast of Blairsden. The reservoir site, at an elevation of 4,360 feet, is on State Highway 89, which would have to be re-routed around the reservoir. State Highway 89 and U. S. Highway 40 Alternate meet at Blairsden. The reservoir is about eight miles from Portola and less than thirty miles from Quincy. Mohawk Valley is part of the Lakes Basin Recreation Area, including Gold Lake which is seven miles to the southwest over a county road. The Johnsville-Eureka Bowl winter sports area, eight miles to the west by county road, and the recreation communities of Graeagle and Mohawk, northwest of the reservoir dam site and near Blairsden, are also included in the Lakes Basin complex.

The reservoir site sits in a fairly large triangular shaped valley surrounded by steep slopes. The reservoir will also be triangular in shape roughly two miles by three and one-half miles.

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1. See Plate IX.

The shoreline is generally regular with the exception of two narrow inlets at the northeast tip.

The normal pool elevation of 4,487 feet will cover an area of 2,200 acres. The reservoir will be constructed primarily for supplementary water storage for production of power at Nelson Point downstream on the Middle Fork. Tentative operation schedules indicate that the drawdown at the end of the summer recreation season will not seriously affect recreation use. However, because of the size, shape and depth of the valley, a heavy drawdown will expose extensive mud flats at the upper end of the valley and affect recreation use and development in that area.

The reservoir area has gradually sloping terrain suitable for recreation development averaging about one-half mile in depth along the southern and western shores. Beyond these areas and on the northern shore the terrain is too steep for most recreational uses, with the exception of some slopes suitable for summer home development. The varied cover consists for the most part of second growth timber with scattered areas of low shrubs and some open areas. The adequacy of suitable terrain and the variety of cover permit a well-balanced recreational development.

Camp and picnic sites are properly located along the southern and eastern shoreline. Organizational camps have been provided mainly at thesoutheastern end of the reservoir with other locations at the northern tip, and on the southern shore. There are open stretches scattered along the southern lakeshore suitable for beach areas.

Lodge and commercial uses have been located at spots around the reservoir easily accessible from the road and other recreational developments. Summer home sites are located back from the reservoir on the slopes which are suitable for such development.

23. CLIO RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	165	825	3,300	379,500	189,750	280,830
Organizational Camps	150	187.5	750	86,250	43,125	52,620
Resort-Commercial	80	200	800	92,000	46,000	72,220
Summer Homes	1,089	1,089	4,356	196,020	98,010	196,020
Total	1,484	2,301.5	9,206	753,770	376,885	601,690

RECREATION USE OF THE MIDDLE FORK OF THE FEATHER RIVER

Plans for development of the Middle Fork of the Feather River have been proposed by the Richvale Irrigation District and the California Department of Water Resources. This section contains an analysis and evaluation of the effect of both plans on the ultimate recreation use of the area.

The Richvale development proposal consists of Grizzly, Clio and Nelson Point Reservoirs, and Minerva Bar, Dogwood Bar, Hartman Bar and Bald Rock Canyon diversion dams and diversion tunnels. Except for Grizzly Reservoir all of the water developments are located on the Middle Fork. Water releases from Grizzly reservoir would flow down Grizzly Creek into the Middle Fork of the Feather River to Clio reservoir. The water stored in Clio would be used to supplement Nelson Point Reservoir storage. Water released from Nelson Point would flow into a diversion tunnel to a power plant and then into Minerva Bar diversion reservoir. From this point, water would subsequently be diverted into tunnels to each power house and diversion dam. This cycle would continue along the Middle Fork until its entrance into Oroville reservoir.

The Richvale plan suggests the type of development presently existing on the North Fork of the Feather River. Unless adequate streamflow releases into the river are provided the recreation attraction and use of the Middle Fork will be seriously impaired.

The Department of Water Resources proposed plan consists of Turntable reservoir on the Middle Fork which would be about one-half the size of Richvale's Nelson Point reservoir. The dam would be about two and one-half miles further upstream from the dam proposed for Nelson Point reservoir. From Turntable water will be diverted in a tunnel to the proposed Meadow Valley reservoir, and from this point water would be again diverted in a tunnel to power plants either on the North Fork or to alternate power plants on the Middle Fork. This combination of reservoirs and diversion tunnels constitutes the Meadow Valley Plan.

Description of the Middle Fork Area

The Middle Fork area is extremely rugged. Canyon slopes are often over fifty percent and land that can be developed for recreation is very limited in the area. Tree cover is generally good, and there are some fairly large areas covered with brush. Sheer cliffs frequently rise from the bed of the river and are obstacles to travel along the river bottom particularly during flood stages. The canyon rims along the river range in elevation from 3,000 to 6,000 feet above mean sea level and stand more than 2,000 feet above the canyon. The river drops from an elevation of about 3,000 feet at Turntable dam site to about 900 feet into Oroville Reservoir.

Below Sloat the Middle Fork is accessible to conventional passenger cars only at Nelson Point and Milsap Bar. There are some jeep trails which can be used by short wheel-base, four-wheel drive vehicles such as the trail into Little California Mine which contains some thirty-four "back-around" switch-backs distributed along its one and one-half mile length. The trail to Cleghorn Bar is slightly better, but the U. S. Forest Service warns that the trail is "dangerous in any vehicle". A large part of the canyon is accessible only by foot trails and some of these have not been maintained and are dangeraus. Some of the "undeveloped" foot trails and deer trails are usable but are also hazardous in many places.

The river is an excellent trout stream - one of the few remaining trout fishing areas in California which has remained in a more or less natural stote. Although access is hazardous for the "tenderfoot", the Middle Fork is one of the favorite fishing streams of local residents who know the hazards and go prepared to "rough it".

Recreation development and use in the Middle Fork area does not now, nor will it in the future, depend entirely on the recreation attraction of the river. Other outstanding recreation attractions are nearby, such as Bucks Lake and Lakes Basin Area, and the inter-relation of these attractions with that of the Middle Fork virtually precludes separation of the recreation use on the basis of the attraction of one particular area. Much of the present use and undoubtedly much of the future use will be of the "other forest areas" type and allocation of such use to the Middle Fork area is impossible with existing data. The area of influence of the Middle Fork is considered to extend from either side of the river to the canyon rims including those areas on the rims which can be developed for recreation use related to the Middle Fork either by vista or by access.

Present and Ultimate Recreation Use of the Middle Fork Area Without Additional Water Development:

Existing recreation use was recorded from the survey of existing recreation areas and facilities. In 1956, recreation facilities consisted of the 12-unit Forest Service campground at Milsap Bar and some 20 permanent and summer homes scattered along the canyon. These facilities received an estimated 16,000 visitor-days recreation use in 1956. Perhaps even more unrecorded use was generated by camping areas in various forms of primitive developments located in the more accessible and usable areas along or above the river.

Ultimate recreation use of the Middle Fork without water development is based on the assumption that future stream-flows will not be significantly different from observed flows. The stream-flow in the Middle Fork has a definite bearing on recreation use of the river. Early season flows during the snow-melt are usually excessive for fishing and many of the accessible usable areas and streamside trails are flooded. As the flow recedes continuous streamside access to the usable areas becomes possible along most of the river.

The Middle Fork area includes some 42 miles of river and roughly 26 miles of live streams flowing into the river from the upper end of either Nelson Point or Turntable Reservoirs to the upper end of Oroville Reservoir. Ultimate recreation use of the area is shown in Table 24.

24. ULTIMATE RECREATION USE OF THE MIDDLE FORK AREA WITHOUT ADDITIONAL WATER DEVELOPMENT, SLOAT TO OROVILLE RESERVOIR, YEAR 2050.

Recreation Use	Acres	Units	Capacity People	Capacity Visitor-days	Annual Visitor-days Use Probable	Annual Visitor-days Use Minimum
Camp & Picnic	352	1,760	7,040	809,600	598,400	404,800
Organizational Camps	230	288	1,150	132,300	80,600	66,300
Resorts	80	200	800	92,000	72,000	46,000
Summer Homes	490	490	1,960	225,400	88,200	44,100
Total	1,152	3,738	10,950	1,259,300	839,200	561,200

Ultimate Recreation Use of the Middle Fork Area With Additional State Water Development

The Meadow Valley plan of the Department of Water Resources shows six miles of the canyon occupied by Turntable Reservoir leaving some 35 miles of downstream recreation area between it and Oroville Reservoir. The California Department of Fish and Game has requested a water release below Turntable of 125 second-feet, or natural flow, whichever is less. While the requested flow will be adequate for proper stream and fish maintenance, thus preserving the recreation attraction of the river, it will not be so great as to flood or restrict access to streamside developable areas. Operation schedules indicate, however, that there will be sufficient run-off to put water over the Turntable spillway about once every ten years and, consequently, the downstream areas may be flooded to some extent during these periods.

The excellent quality of the Middle Fork of the Feather River for trout fishing and propogation, its scenic beauty - including geological formations, vegetation, a clear, live river - and the impracticality of providing extensive motor vehicle access led to the conclusion that the canyon proper should be preserved as a public camping and picnicking area. Access should be limited to hiking and riding trails with some strategically located jeep-trails for service or emergency purposes. A continuous streamside foot-trail system along the 35 miles of river channel should be possible with the regulated maximum stream-flow of 125 second-feet by utilizing gravel bars, rock outcroppings, foot bridges and shallow dams to cross the river at those points where the sheer canyon walls prevent continuous access along one or both banks of the river.

All types of recreation facilities, including organization camps, resorts and summer homes in addition to public camp and picnic areas should be developed at suitable accessible locations along the canyon rims. These facilities, taking advantage of the superb vistas, would serve as transition points from automobile to foot travel into the grandeur of the Middle Fork Canyon. Resorts could serve as control points and provide service facilities such as pack animals, guides, sporting goods, food and other provisions, and parking.

General design concepts were applied in the preparation of the General Recreation Plan, Middle Fork Feather River, Sloat to Oroville, Based on Turntable Reservoir Development, Plate X. The plan was prepared using a composite map of the U. S. Geological Survey Quadrangle maps at a scale of one inch to one mile, with contour intervals of forty feet. The plan shows general locations for some 165 miles of riding and hiking trails with gradients less than ten percent, 24 miles of emergency and service jeep trails and some 26 miles of motor vehicle access roads from existing roads to control points along the canyon rims.

Table 25 shows ultimate recreation use of the developable areas indicated on the plan:

25. ULTIMATE RECREATION USE OF THE MIDDLE FORK AREA AT ULTIMATE DEVELOPMENT WITH ADDITIONAL STATE WATER DEVELOPMENT, TURNTABLE DAM TO OROVILLE RESERVOIR, 2050

Recreation Use	Acres	Units	Capacity People	Capacity Visitor-days	Annual Visitor-days Use Probable	Annual Visitor-days Use Minimum
Camp and Picnic						
Streamside	176	880	3,520	404,800	299,200	202,400
North Canyon Rim	186	930	3,720	427,800	316,200	213,900
South Canyon Rim	162	810	3,240	372,600	275,400	186,300
Sub-total	525	2,620	10,480	1,205,200	890,800	602,600
Organization Camps	470	585	2,340	269,100	163,800	134,500
Resorts						
North Canyon Rim	315	785	3,140	361,100	282,600	180,600
South Canyon Rim	335	835	3,340	384,100	300,600	192,000
Sub-total	650	1,620	6,480	745,200	583,200	372,600
Summer Homes						
North Canyon Rim	695	695	2,780	319,700	125,100	62,600
South Canyon Rim	1,275	1,275	5,100	586,500	229,500	114,800
Sub-total	1,970	1,970	7,880	906,200	354,600	117,400
Totals	3,615	6,795	27,180	3,125,700	1,992,400	1,287,100

Ultimate Recreation Use of the Middle Fork Area With Development of Richvale Irrigation District Plan

Ultimate recreation use from Clio to Sloat would be about the same with additional State or Richvale water development, providing the water releases are adequate. In either case, water releases from Richvale's Clio Reservoir or the State's Grizzly Reservoir, or both, will play an important part in more or less recreation resulting from fishing.

Nelson Point dam would be located about 2.5 miles downstream from the Turntable damsite and some thirty-two miles upstream from the upper end of the Oroville Reservoir. Some nine miles or more of the canyon would be occupied by the reservoir. The four diversion reservoirs downstream from Nelson Point would total about four and one-half miles in length and would not be suitable for recreation use because of turbulence, water level fluctuation, lack of usable land along reservoir shores, rough and dangerous topography and other unsafe conditions. Approximately twenty-seven miles of the river bottom would be suitable for recreation use if adequate stream flow is maintained. Measurement of ultimate recreation use is based on the assumption that a downstream flow of 125 second-feet or natural flow will be maintained in the river.

Plate XI, General Recreation Plan, Middle Fork Feather River, Sloat to Oroville, Based on Nelson Point Reservoir Development, shows thirty miles of roads for recreation use in addition to the estimated twenty miles of roads which will be needed for construction and operational purposes. About thirteen miles of jeep trails and 117 miles of riding and hiking trails are also included in the plan. Recreation facilities and use is contained in Table 26.

26. ULTIMATE RECREATION USE OF THE MIDDLE FORK AREA WITH RICHVALE IRRIGATION DISTRICT WATER DEVELOPMENT, NELSON POINT DAM TO OROVILLE RESERVOIR, 2050

Recreation Use	Acres	Units	Capacity people	Capacity Visitor-day	Annual Visitor-days Use Probable	Annual Visitor-days Use Minimum
Camping and Picnicking						
Streamside	130	650	2,600	299,000	221,000	149,500
North Canyon Rim	165	825	3,300	379,500	280,500	189,750
South Canyon Rim	140	700	2,800	322,000	238,000	161,000
Sub-total	435	2,175	8,700	1,000,500	739,500	500,250
Organization Camps	470	585	2,340	269,100	163,800	134,500
Resorts						
North Canyon Rim	270	675	2,700	310,500	243,000	155,250
South Canyon Rim	254	635	2,540	292,100	228,600	146,050
Sub-total	524	1,310	5,240	602,600	471,600	301,300
Summer Homes						
North Canyon Rim	660	660	2,640	303,600	118,800	59,400
South Canyon Rim	1,275	1,275	5,100	586,500	229,500	114,750
Sub-total	1,935	1,935	7,740	890,100	348,300	174,150
Totals	3,364	6,005	24,020	2,762,300	1,721,200	1,110,200

Comparison of Meadow Valley Plan With Richvale Irrigation District Plan:

At ultimate development the Meadow Valley Plan would create slightly more recreation use than the Richvale Plan considering only the Middle Fork of the Feather River from Sloat to Oroville Reservoir and Turntable and Nelson Point Reservoirs. The development of Clio and Meadow Valley Reservoirs significantly alters the comparative relationship of the total development of each proposed system.

The total Meadow-Valley Plan would safely accommodate thirty percent more people at one time and fifty-three percent more annual visitor-days use than the total Richvale Plan at ultimate development. Recreation facilities and use for each plan can be compared by examining Table 27.

27. ULTIMATE RECREATION USE - MEADOW VALLEY PLAN AND RICHVALE PLAN, 2050

	Middle Fork-Sloat to Oroville		Total System	
Recreation Use	Meadow Valley	Richvale	Meadow Valley	Richvale
Camp and Picnic Units	3,535	3,360	5,285	4,185
Organization Camp Units	585	585	1,229	773
Resort Units	1,988	1,935	2,451	2,135
Summer Home Units	3,174	3,214	5,874	4,303
Total Units	9,282	9,094	14,839	11,396
Capacity People	37,126	36,376	59,352	45,584
Capacity Visitor-days Use	4,269,490	4,183,240	6,825,480	5,242,160
Annual Visitor-days Use				
Probable	2,652,520	2,579,320	4,880,340	3,180,340
Minimum	1,690,435	1,641,610	2,590,430	2,018,495

ULTIMATE ANNUAL RECREATION USE AND NET INCREASES WITH ADDITIONAL WATER DEVELOPMENT

By the year 2050 recreation use with additional development is expected to reach a minimum of 1,039,525 visitor-days annual use and probably 1,651,910 visitor-days annual use for the five authorized reservoir areas. The reservoir areas under study, excluding Swayne and Humbug, are expected to have minimum and probable visitor-days annual use of 3,457,810 and 5,440,390, respectively. Total ultimate recreation use for all project areas, including authorized, those under study, and Swayne and Humbug, will reach a minimum of 5,146,580 and probably 7,092,300 visitor-days annual use by 2050. The proposed Richvale projects of Nelson Point and Clio Reservoirs are expected to have an ultimate recreation use of 908,300 and 1,460,970, minimum and probable visitor-days use, respectively. Table 28 summarizes the minimum and Table 29 the probable ultimate recreation visitor-days annual use for each reservoir area by type of recreation facility. Net increase in ultimate, minimum, and probable recreation visitor-days annual use of reservoir areas with additional water development are shown in Tables 30 and 31. These increases are based on the reservoir site development plans.

With additional water development ultimate minimum recreation use for the five authorized projects is expected to increase four and one-half times the recreation use that may develop without additional water development, or a net increase of 817,225 visitor-days annual use. Ultimate probable use will have about the same percentage increase of 1,302,733 visitor-days annual use for the five authorized reservoir areas. The proposed reservoir areas, excluding Swayne and Humbug, will increase in recreation use over six times or a net minimum and probable increase of 2,907,786 and 4,577,996 visitor-days annual use, respectively. All project areas, except Nelson Point and Clio, will have a net minimum and probable increase of five and one-half times with additional water development, or 4,201,574 minimum and 6,644,534 probable visitor-days annual use by 2050. The Richvale projects would have a net increase of 688,283 and 1,115,325 minimum and probable visitor-days annual use or more than five times the recreation use expected without additional water development.

28. ULTIMATE MINIMUM RECREATION VISITOR-DAYS ANNUAL USE WITH ADDITIONAL WATER DEVELOPMENT BY RECREATION FACILITY, 2050

	Camp & Picnic	Organization Camps	Resorts	Summer Homes	Total
Authorized Projects					
Grizzly Valley	176,180	21,900	28,080	71,310	297,470
Antelope Valley	117,300	18,900	12,960	45,510	194,670
Abbey Bridge	107,640	15,175	16,200	42,740	181,755
Dixie Refuge	80,500	12,675	9,720	31,830	134,725
Frenchman	137,080	17,675	21,600	54,550	230,905
Sub-total (1)	618,700	86,325	88,560	245,940	1,039,525
Reservoirs under study					
Squaw Queen	437,000	140,875	146,625	261,000	985,500
Sheep Camp	218,500	58,880	69,000	98,100	444,480
Turntable	210,450	-	84,525	108,360	403,335
Meadow Valley	402,500	148,120	106,375	243,000	899,995
Genesee Valley Park	644,000	-	80,500	-	724,500
Sub-total (2)	1,912,450	347,875	487,025	710,460	3,457,810
Swayne	189,750	21,620	41,400	65,700	318,470
Humbug	161,000	34,500	48,875	86,400	330,775
Sub-total (3)	350,750	56,120	90,275	152,100	649,245
Richvale Projects					
Nelson Point	272,550	-	143,750	115,110	531,410
Clio	189,750	43,130	46,000	98,010	376,890
Sub-total (4)	462,300	43,130	189,750	213,120	908,300
Total (1) & (2)	2,531,150	434,200	575,585	956,400	4,497,335
Total (1), (2) & (3)	2,881,900	490,320	665,860	1,108,500	5,146,580

29. ULTIMATE PROBABLE RECREATION VISITOR-DAYS ANNUAL USE WITH ADDITIONAL WATER DEVELOPMENT BY RECREATION FACILITY, 2050

	Camp & Picnic	Organization Camps	Resorts	Summer Homes	Total
Authorized Projects					
Grizzly Valley	260,750	26,720	44,090	142,620	474,180
Antelope Valley	173,600	23,060	20,350	91,020	308,030
Abbey Bridge	159,310	18,510	25,430	85,480	288,730
Dixie Refuge	119,140	15,460	15,260	63,660	213,520
Frenchman	202,880	21,560	33,910	109,100	367,450
Sub-total (1)	915,680	105,310	139,040	491,880	1,651,910
Reservoirs under study					
Squaw Queen	646,760	171,870	230,200	522,000	1,570,830
Sheep Camp	323,380	71,830	108,330	196,200	699,740
Turntable	311,470	-	132,700	216,720	660,890
Meadow Valley	595,700	180,710	167,010	486,000	1,429,420
Genesee Valley Park	953,120	-	126,390	-	1,079,510
Sub-total (2)	2,830,430	424,410	764,630	1,420,920	5,440,390
Swayne	280,830	26,380	65,000	131,400	503,610
Humbug	238,280	42,090	76,730	172,800	529,900
Sub-total (3)	519,110	68,470	141,730	304,200	1,035,510
Richvale Projects					
Nelson Point	403,370	-	225,690	230,220	859,280
Clio	280,830	52,620	72,220	196,020	601,690
Sub-total (4)	684,200	52,620	297,910	426,240	1,460,970
Total (1) & (2)	3,746,110	529,720	903,670	1,912,800	7,092,300
Total (1), (2) & (3)	4,265,220	598,190	1,045,400	2,217,000	8,125,810

30. NET INCREASES IN MINIMUM ULTIMATE RECREATION VISITOR-DAYS ANNUAL USE RESULTING FROM ADDITIONAL WATER DEVELOPMENT BY RECREATION FACILITY, 2050

Reservoir Area	Camp & Picnic	Organization Camps	Resorts	Summer Homes	Total
Authorized Projects					
Grizzly Valley	121,900	21,035	23,760	59,250	225,945
Antelope Valley	83,260	18,454	9,936	37,950	149,600
Abbey Bridge	76,820	14,745	14,040	35,810	141,415
Dixie Refuge	57,316	12,362	7,647	26,610	103,935
Frenchman	110,860	17,330	19,440	48,700	196,330
Sub-total (1)	450,156	83,926	74,823	208,320	817,225
Reservoirs under study					
Squaw Queen	325,680	139,322	136,689	236,160	837,851
Sheep Camp	196,420	58,190	67,920	96,390	418,920
Turntable	144,210	- 863	78,585	93,600	315,532
Meadow Valley	290,260	146,050	96,371	217,800	750,481
Genesee Valley Park	538,660	- 1,380	71,212	-23,490	585,003
Sub-total (2)	1,495,230	341,319	450,777	620,460	2,907,786
Swayne	107,824	20,585	32,016	47,376	207,801
Humbug	118,496	29,325	44,045	76,896	268,762
Sub-total (3)	226,320	49,910	76,061	124,272	476,563
Richvale Projects					
Nelson Point	187,082	-1,208	133,952	95,994	415,820
Clio	112,470	42,095	37,168	80,730	272,463
Sub-total (4)	299,552	40,887	171,120	176,724	688,283
Total (1) & (2)	1,945,386	425,245	525,600	828,780	3,725,011
Total (1), (2) & (3)	2,171,706	475,155	601,661	953,052	4,201,574

31. NET INCREASES IN PROBABLE ULTIMATE RECREATION VISITOR-DAYS ANNUAL USE RESULTING FROM ADDITIONAL WATER DEVELOPMENT BY RECREATION FACILITY, 2050

Reservoir Area	Camp & Picnic	Organization Camps	Resorts	Summer Homes	Total
Authorized Projects					
Grizzly Valley	180,416	25,667	37,308	118,500	361,891
Antelope Valley	123,221	22,513	15,602	75,900	237,236
Abbey Bridge	113,696	17,984	22,039	71,620	225,339
Dixie Refuge	84,828	15,082	12,005	53,220	165,135
Frenchman	164,074	21,139	30,519	97,400	313,132
Sub-total (1)	666,235	102,385	117,473	416,640	1,302,733
Reservoirs under study					
Squaw Queen	482,006	169,975	214,600	472,320	1,338,901
Sheep Camp	290,702	70,988	106,634	192,780	661,104
Turntable	213,435	- 1,053	123,374	187,200	522,956
Meadow Valley	429,585	178,185	151,304	435,600	1,194,674
Genesee Valley Park	797,217	- 1,684	111,808	-46,980	860,361
Sub-total (2)	2,212,945	416,411	707,720	1,240,920	4,577,996
Swayne	159,580	25,117	50,267	94,752	329,716
Humbug	175,374	35,776	69,147	153,792	434,089
Sub-total (3)	334,954	60,893	119,414	248,544	763,805
Richvale Projects					
Nelson Point	276,877	-1,474	210,307	191,988	677,698
Clio	166,456	51,357	58,354	161,460	437,627
Sub-total (4)	443,333	49,883	268,661	353,448	1,115,325
Total (1) & (2)	2,879,180	518,796	825,193	1,657,560	5,880,729
Total (1), (2) & (3)	3,214,134	579,689	944,607	1,906,104	6,644,534

PART VI. BENEFIT-COST EVALUATION OF RESERVOIR AREAS UNDER STUDY AND THE MIDDLE FORK OF FEATHER RIVER WITH AND WITHOUT ADDITIONAL WATER DEVELOPMENT

A comparison of the estimated cost of a project to the estimated net benefits accruing from its operation can be stated simply in the form of a benefit-cost ratio. This benefit-cost ratio is used as an indicator of the economic justification for incurring the costs of a project in order to receive the benefits. For that project to be economically justified, the dollar benefits estimated to be derived from the operation of a water reservoir, all other conditions favorable, must be the same as or greater than the estimated dollar cost of construction and operation. The evaluation in this Part is concerned with those net dollar benefits and costs directly attributable to and resulting from the public (camp and picnic) recreation use and development at the site of each of the reservoirs for the fifty-year pay-out period to determine whether the recreational development at each reservoir is economically justified. Indirect effects of the project development in adjacent portions of the Upper Basin are not considered.

The basis for benefit-cost evaluation of the recreation use and development is the site development plan, prepared for each reservoir area, and the general development plan prepared for that portion of the Middle Fork of the Feather River from Sloat to Oroville Reservoir.

BENEFITS AND COSTS

At the time the first five reservoirs (now authorized) were studied in 1956, and the summary report on them published in early 1957, final analysis of research data and field survey covering probable recreation use (measured as a percentage of capacity use) had not been completed. Enough information had been gathered and analyzed to indicate that a conservative (thereby reasonable) probable use would be fifty percent of capacity use and this percentage was applied to the five authorized reservoir areas. Final analysis showed the percentage of use and the capacity for use to be much too conservative. All of the reservoirs subsequently studied and the Middle Fork of the Feather River included the new probable recreation use figures. The older probable recreation use figures that were applied to the five reservoirs were retained as minimum recreation use.

Both probable and minimum benefits are shown for the reservoirs under study and for the five authorized reservoirs as a basis for direct comparisons. The new probable benefits are significantly greater (by 48%) than the former probable benefits.

The dollar benefits obtained from recreation use were computed by applying the $2.00 per visitor-day figure to the net increase in use due to the construction and operation of the reservoirs and public (camp and picnic) recreation facilities. Derivation of the $2.00 figure is discussed in Part VIII contained in the Appendix.

Recreation costs are construed to be those for the installation of public facilities (camp and picnic) and the construction of the additional roads required to serve these facilities. Unit capital construction costs and unit operating, maintenance and replacement costs of these facilities and roads were developed and are discussed in a subsequent section. Capital costs were computed for each year from 1961 to 2010 by application of the unit costs to the number of new camp and picnic units and miles of road constructed. Operating, maintenance and replacement costs were computed for each year by applying unit costs to the net increase in number of camp and picnic units resulting from reservoir construction and miles of road constructed. All the costs were then combined for each year.

The dollar benefits and costs were adjusted to "present worth" by discounting both benefits and costs for each year at three percent, cumulatively, beginning in the year 1961. Thus the present worth of benefits and costs in the year 1961 are computed at 97.1 percent of actual dollar value for that year. For the year 2010 - the end of the fifty-year pay-out period - the present worth factor is 22.8 percent. Cumulative 50 year present worth benefits and costs were then converted to annual equivalents. The annual equivalent cost represents the annual sum required to amortize the capital investment and to pay operating, maintenance and replacement expenses, which would be offset by the annual equivalent benefit. The benefit-cost ratio is a mathematical statement of the direct relationship of present worth costs or their annual equivalents.

The fifty-year cumulative total present worth benefits and costs and their annual equivalents were computed for the reservoir areas but not for the Middle Fork of the Feather River -- or what has been, and will be, referred to as the total Meadow Valley Plan and the total Richvale Irrigation District Plan. Fifty-year cumulative total benefits and costs for the Middle Fork could not be adjusted to present worth and their annual equivalents because of the general nature of plan and the primary interest in the proposed reservoir project areas themselves.

Recreation costs that were used in 1956 when the five authorized reservoirs were studied have increased approximately twenty percent in two years. Unit construction (capital) costs for public recreation facilities and roads were $750 for one camp or picnic unit and $25,000 per mile of road. Annual operation, maintenance and replacement costs were $105 for one camp or picnic unit and $400 per mile of road.[1] These costs were developed after interviews and discussions with State and Federal officials concerned with providing similar facilities in State and National parks and forests; the consultant's experience and knowledge in the

1. Appendix A, Bulletin No. 59, op. cit.

field of landscape architecture, and the experience of other practicing landscape architects, both in public and private practice.

Development costs of camp and picnic areas includes preparation of the site, removal of dangerous trees, installation of traffic control barriers, water systems, sanitary facilities, laundry and shower facilities, tables, fireplaces, food lockers, parking spurs, and tent and trailer sites. The cost per unit varies with topography, locality, improvements included and availability of water. However, the big variable is the cost of providing safe water.

Subsequent discussions with Federal officials disclosed that costs have risen in the past few years. The U. S. Forest Service in its Operation Outdoors program, has estimated that a reasonable average cost nationally for developing one new camp and picnic family unit to be $860.[1] Further discussions and analysis led to the adoption of camp and picnic costs of $1,000 per unit capital cost and $126 per unit annual operation, maintenance and replacement cost. Road capital costs were also increased to $42,000 per mile for major feeder roads and $20,000 per mile for access (service) roads. Capital cost for a trail is estimated to be $700 per mile. Road and trail annual operation, maintenance and replacement costs are now estimated to be $500 and $34 per mile, respectively. A breakdown of the unit costs is contained in Table 32.

Unit capital costs and unit annual operation, maintenance and replacement costs for public facilities in Genesee Valley Park were increased to $1,316 and $208 per unit respectively because of the addition of other necessary recreation and utility developments to serve the ultimate designed capacity of the area. The development plan for the area shows that there will ultimately be 2,800 camp and picnic units and 350 lodge units having a daily capacity

1. U. S. Forest Service, Operation Outdoors, 1957, p. 13.

32. UNIT COSTS OF PUBLIC (CAMP AND PICNIC) RECREATION FACILITIES AND ROADS

Capital Costs of One Camp and Picnic Unit:	
Clearing and grading	$ 30
Paved parking area for one car and traffic control barriers	130
Table, food locker, and fireplace	125
Water supply and lines	55
Electric lines	30
Comfort station (five toilets, two urinals, septic tank and drain lines) -- one for each fifty units	160
Comfort station, shower and laundry (five toilets, two urinals, four showers, two laundry tubs, septic tank and drain lines) -- one for each fifty units	260
Shop and equipment building -- one for each 200 units	40
Office and housing for personnel -- one for each 200 units	80
Miscellaneous (signs, garbage cans, etc.)	90
Total capital cost	$ 1,000
Capital Costs per Mile of Road and Trail Construction:	
Major Feeder Road -- Sixty feet of right-of-way; two eleven-foot wide asphaltic concrete travel lanes, two inches thick; base course of crushed rocks or gravel covering travel lanes and two six-foot wide shoulders, six inches thick	$ 42,000
Improving Existing Major Feeder Road	20,000
Access (Service) Road -- Fifty feet of right-of-way; two ten-foot wide travel lanes, armor coat; base course of crushed rock or gravel covering travel lanes and two two-foot wide shoulders, four inches thick	20,000
Improving Existing Access Road	10,000
Trail	700
Annual Operation, Maintenance and Replacement Costs:	
Camp and Picnic Unit:	
Power and Supplies	$ 14
Salaries	57
Maintenance	15
Replacement in twenty-five years	40
Total	$ 126
Road maintenance and replacement in twenty-five years (per mile)	$ 500
Trail maintenance (per mile)	$ 34

of 12,600 visitors. With a designed increased density of recreation development and use, consideration will have to be given to the need for a more highly developed water system and sewerage system.

Liberal use of water should be deliberately included in this consideration, because of increased consumption and use which will reach an estimated 150 gallons per person per day. The usual one and one-half day's supply and adequate volume of water to meet fire requirements must also be considered. Table 33 shows the estimated additional costs of developing the added facilities. Road and trail costs remain the same as for the other reservoir areas and are not included in this table.

Although Table 33 specifically shows $190,000 for water and sewer systems, there are additional funds for these purposes incorporated in the other developments such as beaches, play areas and amphitheatre area, amounting to $160,000. In addition, there would be the other camp and picnic funds for water and sewerage purposes which can be combined with the aforementioned amounts to pay for the installation of a first-class water and sewerage system. Detailed design study would, of course, take this into consideration as well as the other facilities, needs and requirements.

BENEFITS AND COSTS - RESERVOIR AREAS

Recreation use of the reservoir areas was projected over a ninety-year period begining in 1960, when necessary roads and camp and picnic facilities will have been installed and reservoirs will be at operating levels, and extending to year 2050. It was assumed that use, measured in visitor-days, will increase at a fairly uniform rate over the ninety-year period, the rate of increase being somewhat greater in the first half of the period than the second period when saturation will be approached.

33. ESTIMATED COSTS OF ADDITIONAL FACILITIES IN GENESEE VALLEY PARK

Additional Capital Costs	Estimated Total	Costs per Camp and Picnic Unit
Water and Sewer System	$ 190,000	$ 68
Beaches -- including clearing and grading 14 acres; transporting sand; 162 picnic tables; parking areas for 280 cars; water and sewer lines and equipment	103,000	37
Play Areas -- including clearing and grading 28 acres; play equipment; shelters; turf; parking areas for 280 cars; water and sewer lines and equipment	190,000	68
Amphitheatre (seating 1500 persons) -- including clearing, grading, turfing and landscaping four acres; seats; stage, rooms and equipment; parking areas for 300 cars; lighting and electrical equipment; water and sewer lines and equipment	112,000	40
Power and Telephone Lines	110,000	39
Administration Building, Area and Equipment	40,000	14
Control Station Buildings and Equipment (four)	30,000	11
Service and Maintenance Building, Area and Equipment -- including trucks, grading equipment, boats, and tools	110,000	39
Total additional capital cost	$ 885,000	$ 316
Additional Annual Operation, Maintenance and Replacement Costs:		
Maintenance Expenses	$ 17,000	$ 6
Replacement in twenty-five years (five years for maintenance equipment)	56,000	20
Salaries for Personnel -- including 14 administrative, twelve lifeguards, sixteen recreation supervisors, ten maintenance	158,000	56
Total additional annual operation, maintenance and replacement cost	$ 231,000	$ 82

Recreation benefits from the proposed reservoir projects are based on use during the first fifty years of the life of the projects, or from 1960 to 2010, and for project feasibility purposes only the use of facilities constructed with public funds is considered (camp and picnic facilities and necessary roads). Cumulative minimum and probable use during this fifty-year pay-out period has been calculated, both with and without additional water development, for "public" facilities and all facilities as shown in Tables 34 and 35. The difference between use without additional water development and use with additional water development is the basis for measuring the net recreation benefit from the construction of the reservoirs. This is shown as the net increase in the tables.

Net benefits and costs resulting from additional water development of the reservoir areas are the net cumulative totals for the fifty-year pay-out period for both public recreation and all recreation. Both probable and minimum benefits, and 1958 and 1956 costs have been included except for the first five authorized reservoirs and Genesee Valley Park. In the case of the first five authorized reservoirs, 1958 costs were not computed; and in the case of Genesee Valley Park 1956 costs were not shown, since they have no application to the increased unit costs which were developed in 1958 and which are not comparable to the "normal" reservoir unit costs.

Table 36 shows the net cumulative total public recreation probable and minimum benefits and 1958, and 1956 costs. The total net cumulative probable benefit for the seven reservoir areas under study would be $72,000,000 at the end of the year 2010; minimum benefit would be $48,587,000. The 1958 cost for these reservoir areas would be $20,924,000.

Table 37 contains the benefits and costs with the same arrangement as in Table 36, but the total figures have been adjusted to present worth benefits and costs. Table 38 is arranged in the same manner as Table 37, but the figures have been adjusted to average annual equivalents. Table 39 contains the benefit-cost ratios for the various combinations of probable and minimum benefits to 1958 and 1956 costs.

Tables 40 and 41 contain the same general arrangement as in the preceding tables, but deal with total recreation benefits which include, in addition to public (camp and picnic) benefits, the benefits that will be obtained from organization camps, resort and commercial uses, and summer homes. Total recreation benefits have also been related to public costs to show the total effect of public expenditures in the development of the reservoir areas.

34. CUMULATIVE PUBLIC (CAMP & PICNIC) RECREATION VISITOR-DAYS ANNUAL USE OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010

Reservoir Area	Minimum Visitor-days Use: Without Reservoir,	Minimum Visitor-days Use: With Reservoir	Minimum Visitor-days Use: Net Increase	Probable Visitor-days Use: Without Reservoir	Probable Visitor-days Use: With Reservoir	Probable Visitor-days Use: Net Increase
Authorized Projects						
Grizzly Valley	237,550	2,208,150	1,970,600	351,570	3,268,060	2,916,490
Antelope Valley	101,500	1,882,350	1,690,850	283,420	2,785,880	2,502,460
Abbey Bridge	163,850	1,818,650	1,654,800	242,500	2,691,600	2,449,100
Dixie Refuge	162,600	1,476,050	1,313,450	240,650	2,184,550	1,943,900
Frenchman	177,950	1,819,850	1,641,900	263,370	2,693,380	2,430,010
Sub-total (1)	933,450	9,205,050	8,271,600	1,381,510	13,623,470	12,241,960
Reservoirs under study						
Squaw Queen	891,000	5,278,750	4,387,750	1,318,680	7,812,550	6,493,870
Sheep Camp	160,750	2,881,750	2,721,000	237,910	4,264,990	4,027,080
Turntable	424,650	2,645,500	2,220,850	628,480	3,915,340	3,286,860
Meadow Valley	560,500	5,005,250	4,444,750	829,540	7,407,770	6,578,230
Genesee Valley Park	500,700	8,218,750	7,718,050	741,040	12,163,750	11,422,710
Sub-total (2)	2,537,600	24,030,000	21,492,400	3,755,650	35,564,400	31,808,750
Swayne	926,300	2,284,000	1,357,700	1,370,920	3,380,320	2,009,400
Humbug	428,300	1,872,000	1,443,700	633,880	2,770,560	2,136,680
Sub-total (3)	1,354,600	4,156,000	2,801,400	2,004,800	6,150,880	4,146,080
Richvale Projects						
Nelson Point	901,750	3,355,250	2,453,500	1,334,590	4,965,770	3,631,180
Clio	838,800	2,298,750	1,459,950	1,241,420	3,402,150	2,160,730
Sub-total (4)	1,740,550	5,654,000	3,913,450	2,576,010	8,367,920	5,791,910
Total (1) & (2)	3,471,050	33,235,050	29,764,000	5,137,160	49,187,870	44,050,710
Total (1), (2) & (3)	4,825,650	37,391,050	32,565,400	7,141,960	55,338,750	48,196,790

35. CUMULATIVE TOTAL RECREATION VISITOR-DAYS ANNUAL USE OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010

Reservoir Area	Minimum Visitor-days Use			Probable Visitor-days Use		
	Without Reservoir	With Reservoir	Net Increase	Without Reservoir	With Reservoir	Net Increase
Authorized Projects						
Grizzly Valley	338,100	3,357,650	3,119,550	530,820	5,511,490	4,980,670
Antelope Valley	247,200	2,951,650	2,704,450	388,350	4,669,510	4,281,160
Abbey Bridge	241,750	2,383,250	2,141,500	379,790	3,786,980	3,407,190
Dixie Refuge	204,650	2,349,450	2,144,800	321,500	3,723,880	3,402,380
Frenchman	232,750	2,764,550	2,531,800	365,650	4,398,400	4,032,750
Sub-total (1)	1,264,450	13,906,550	12,642,100	1,986,110	22,090,260	20,104,150
Reservoirs under study						
Squaw Queen	1,208,500	11,544,750	10,336,250	1,898,550	18,402,330	16,503,780
Sheep Camp	193,900	5,653,500	5,459,600	292,980	8,898,610	8,605,630
Turntable	579,600	5,093,250	4,513,650	910,550	8,347,840	7,437,290
Meadow Valley	969,000	10,862,250	9,893,250	1,521,330	17,249,250	15,727,920
Genesee Valley Park	687,900	9,453,750	8,765,850	1,080,690	14,086,090	13,005,400
Sub-total (2)	3,638,900	42,607,500	38,968,600	5,704,100	66,984,120	61,280,020
Swayne	1,176,050	4,009,250	2,833,200	1,847,570	6,338,620	4,491,050
Humbug	757,500	4,060,750	3,303,250	1,170,340	6,505,320	5,334,980
Sub-total (3)	1,933,550	8,070,000	6,136,450	3,017,910	12,843,940	9,826,030
Richvale Projects						
Nelson Point	1,218,500	6,516,000	5,297,500	1,914,260	10,536,370	8,622,110
Clio	1,208,700	4,530,750	3,322,050	1,898,870	7,231,080	5,332,210
Sub-total (4)	2,427,000	11,046,750	8,619,550	3,813,130	17,767,450	13,954,320
Total (1) & (2)	4,903,350	56,514,050	51,610,700	7,690,210	89,074,380	81,384,170
Total (1), (2) & (3)	6,836,900	64,584,050	57,747,150	10,708,120	101,918,320	91,210,200

36. NET CUMULATIVE TOTAL PUBLIC RECREATION BENEFITS AND COSTS OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010*

Reservoir Area	Benefits Probable	Benefits Minimum	Costs 1958	Costs 1956
Authorized Projects				
Grizzly Valley	$ 5,832,980	$ 3,941,200	$ ---	$ 1,445,175
Antelope Valley	5,004,920	3,381,700	---	1,211,895
Abbey Bridge	4,898,200	3,309,600	---	1,272,150
Dixie Refuge	3,887,800	2,626,900	---	978,490
Frenchman	4,860,020	3,283,800	---	1,229,740
Sub-total (1)	24,483,920	16,543,200		6,137,450
Reservoirs under study				
Squaw Queen	$12,987,740	$ 8,775,500	$ 3,689,343	$ 2,983,076
Sheep Camp	8,054,160	5,442,000	2,274,019	1,846,986
Turntable	6,573,720	4,441,700	1,913,049	1,549,400
Meadow Valley	13,156,460	8,889,500	3,707,149	2,977,298
Genesee Valley Park	22,845,420	15,436,100	9,341,293	---
Sub-total (2)	63,617,500	42,984,800	20,924,853	9,356,760
Swayne	$ 4,018,800	$ 2,715,400	$ 1,306,252	$ 1,049,569
Humbug	4,273,360	2,887,400	1,257,951	1,014,092
Sub-total (3)	8,392,160	5,602,800	2,564,203	2,063,661
Richvale Projects				
Nelson Point	$ 7,262,360	$ 4,907,000	$ 2,277,174	$ 1,839,319
Clio	4,321,452	2,919,900	1,398,051	1,124,677
Sub-total (4)	11,583,812	7,826,900	3,675,225	2,963,996
Total (1) & (2)	88,101,420	59,528,000	---	---
Total (2) & (3)	72,009,660	48,587,600	23,489,056	---
Total (1), (2) & (3)	96,493,580	65,130,800	---	---

* Not adjusted to present worth.

37. NET CUMULATIVE TOTAL PRESENT WORTH PUBLIC RECREATION BENEFITS AND COSTS OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010

Reservoir Area	Benefits Probable	Benefits Minimum	Costs 1958	Costs 1956
Authorized Projects				
Grizzly Valley	$ 2,263,133	$ 1,529,144	$ ---	$ 623,220
Antelope Valley	2,025,247	1,368,410	---	565,814
Abbey Bridge	1,927,306	1,302,234	---	566,832
Dixie Refuge	1,602,930	1,083,061	---	469,921
Frenchman	1,901,588	1,284,857	---	537,062
Sub-total (1)	9,720,204	6,567,706	---	2,762,849
Reservoirs under study				
Squaw Queen	4,926,390	3,328,642	1,494,754	1,203,970
Sheep Camp	3,134,104	2,117,638	934,827	755,655
Turntable	2,554,572	1,726,062	794,717	645,728
Meadow Valley	4,966,820	3,355,960	1,485,463	1,189,715
Genesee Valley Park	8,744,700	5,908,581	3,793,079	---
Sub-total (2)	24,326,586	16,436,883	8,503,840	3,795,068
Swayne	1,533,155	1,035,916	535,284	428,709
Humbug	1,586,114	1,071,699	498,396	400,311
Sub-total (3)	3,119,269	2,107,615	1,033,680	829,120
Richvale Projects				
Nelson Point	2,843,456	1,921,254	946,152	762,209
Clio	1,697,504	1,146,962	585,978	469,909
Sub-total (4)	4,540,960	3,068,216	1,532,130	1,232,118
Total (1) & (2)	34,046,790	23,004,589	---	---
Total (2) & (3)	27,445,855	18,544,498	9,537,520	---
Total (1), (2) & (3)	37,166,059	25,112,204	---	---

38. AVERAGE ANNUAL EQUIVALENT PRESENT WORTH PUBLIC RECREATION BENEFITS AND COSTS OF RESERVOIR AREAS FOR THE NET CUMULATIVE TOTAL FIFTY-YEAR PAYOUT PERIOD, 1961-2010

	Benefits		Costs	
Reservoir Area	Probable	Minimum	1958	1956
Authorized Projects				
Grizzly Valley	87,967	59,437	----	24,224
Antelope Valley	78,721	52,190	----	21,993
Abbey Bridge	74,913	50,617	----	22,032
Dixie Refuge	62,305	42,098	----	18,265
Frenchman	73,914	49,942	----	20,875
Sub-total (1)	377,820	255,284	----	107,389
Reservoirs under study				
Squaw Queen	191,489	129,384	58,101	46,798
Sheep Camp	121,823	82,313	36,337	29,372
Turntable	99,296	67,092	30,890	25,099
Meadow Valley	193,060	130,446	57,779	46,244
Genesee Valley Park	339,906	229,667	147,437	----
Sub-total (2)	945,574	638,902	330,544	147,513
Swayne	59,594	40,266	20,806	16,664
Humbug	61,653	41,657	19,333	15,560
Sub-total (3)	121,247	81,923	40,139	32,224
Richvale Projects				
Nelson Point	110,525	74,679	36,777	29,627
Clio	65,982	44,582	22,777	18,265
Sub-total (4)	176,507	119,261	59,554	47,892
Total (1) & (2)	1,323,394	894,186	----	----
Total (2) & (3)	1,066,821	720,825	370,683	----
Total (1), (2) & (3)	1,444,641	976,109	----	----

39. NET CUMULATIVE TOTAL PRESENT WORTH PUBLIC RECREATION BENEFIT -- COST RATIOS OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010.

Reservoir Area	Probable Benefits 1958 Costs	Probable Benefits 1956 Costs	Minimum Benefits 1958 Costs	Minimum Benefits 1956 Costs
Authorized Projects				
Grizzly Valley	---	3.631:1	---	2.454:1
Antelope Valley	---	3.579:1	---	2.418:1
Abbey Bridge	---	3.400:1	---	2.297:1
Dixie Refuge	---	3.411:1	---	2.305:1
Frenchman	---	3.541:1	---	2.392:1
Sub-total (1)	---	3.518:1	---	2.377:1
Reservoirs under study				
Squaw Queen	3.295:1	4.092:1	2.227:1	2.765:1
Sheep Camp	3.352:1	4.147:1	2.265:1	2.802:1
Turntable	3.206:1	3.956:1	2.172:1	2.673:1
Meadow Valley	3.341:1	4.175:1	2.257:1	2.820:1
Genesee Valley Park	2.305:1	---	1.558:1	---
Sub-total (2)	2.861:1	---	1.933:1	---
Swayne	2.864:1	3.576:1	1.934:1	2.416:1
Humbug	3.182:1	3.962:1	2.150:1	2.677:1
Sub-total (3)	3.021:1	3.762:1	2.041:1	2.542:1
Richvale Projects				
Nelson Point	3.005:1	3.730:1	2.031:1	2.521:1
Clio	2.897:1	3.612:1	1.975:1	2.441:1
Sub total (4)	2.964:1	2.963:1	2.002:1	2.490:1
Total (1) & (2)	---	---	---	---
Total (2) & (3)	2.878:1	---	1.945:1	---
Total (1), (2) & (3)	---	---	---	---

40. NET CUMULATIVE TOTAL RECREATION BENEFITS AND TOTAL PRESENT WORTH BENEFITS OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010.

	Total Benefits		Present Worth Benefits	
Reservoir Area	Probable	Minimum	Probable	Minimum
Authorized Projects:				
Grizzly Valley	$ 9,961,340	$ 6,239,100	$ 3,701,888	$ 2,318,609
Antelope Valley	8,562,320	5,408,900	3,417,114	2,158,624
Abbey Bridge	6,814,380	4,283,000	2,663,729	1,674,217
Dixie Refuge	6,804,760	4,289,600	2,745,312	1,730,596
Frenchman	8,065,500	5,063,600	3,014,265	1,892,385
Sub-total (1)	40,208,300	25,284,200	15,542,308	9,774,431
Reservoirs under study:				
Squaw Queen	33,007,560	20,672,500	12,084,396	7,568,405
Sheep Camp	17,211,260	10,919,200	6,603,435	4,189,359
Turntable	14,874,580	9,027,300	5,749,701	3,489,468
Meadow Valley	31,455,840	19,786,500	11,924,653	7,500,914
Genesee Valley Park	26,010,800	17,531,700	10,019,818	6,753,524
Sub-total (2)	122,560,040	77,937,200	46,382,003	29,501,670
Swayne	8,982,100	5,299,100	3,436,094	2,027,170
Humbug	10,669,960	6,606,500	3,976,240	2,461,962
Sub-total (3)	19,652,060	11,905,600	7,412,334	4,489,132
Richvale Projects:				
Nelson Point	17,244,220	10,595,000	6,611,636	4,062,250
Clio	10,664,420	6,644,100	4,015,902	2,501,970
Sub-total (4)	27,908,640	17,239,100	10,627,538	6,564,220
Total (1) and (2)	162,768,340	103,221,400	61,924,311	39,276,101
Total (2) and (3)	142,212,100	89,842,800	53,794,337	33,990,802
Total (1), (2) and (3)	182,420,400	115,127,000	69,336,645	43,765,233

41. AVERAGE ANNUAL EQUIVALENT PRESENT WORTH TOTAL RECREATION BENEFITS AND PRESENT WORTH TOTAL RECREATION BENEFIT-PUBLIC COST RATIOS OF RESERVOIR AREAS FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010

Reservoir Area	Probable Benefits: Average Annual Equivalent	Probable Benefits: Benefit-Cost Ratio 1958 Costs	Probable Benefits: Benefit-Cost Ratio 1956 Costs	Minimum Benefits: Average Annual Equivalent	Minimum Benefits: Benefit-Cost Ratio 1958 Costs	Minimum Benefits: Benefit-Cost Ratio 1956 Costs
Authorized Projects:						
Grizzly Valley	$ 143,892	---	5.940:1	$ 90,124	---	3.720:1
Antelope Valley	132,823	---	6.039:1	83,905	---	3.959:1
Abbey Bridge	103,539	---	4.699:1	65,076	---	2.954:1
Dixie Refuge	106,710	---	5.842:1	67,268	---	3.683:1
Frenchman	117,164	---	5.613:1	73,557	---	3.524:1
Sub-total (1)	604,128	---	5.626:1	379,930	---	3.538:1
Reservoirs under study:						
Squaw Queen	469,720	8.084:1	10.037:1	294,183	5.063:1	6.735:1
Sheep Camp	256,676	7.064:1	8.739:1	162,840	4.481:1	5.544:1
Turntable	223,490	7.235:1	8.904:1	135,635	4.391:1	5.404:1
Meadow Valley	463,511	6.839:1	10.023:1	291,561	5.046:1	6.304:1
Genesee Valley Park	389,470	2.642:1	---	262,509	1.780:1	---
Sub-total (2)	1,802,867	5.454:1	---	1,146,728	3.469:1	---
Swayne	133,561	6.419:1	8.015:1	78,796	3.787:1	4.729:1
Humbug	154,556	7.978:1	9.933:1	95,696	4.939:1	6.150:1
Sub-total (3)	288,117	7.178:1	8.941:1	174,492	4.347:1	5.415:1
Richvale Projects:						
Nelson Point	256,994	6.988:1	8.674:1	157,900	4.293:1	5.330:1
Clio	156,098	6.853:1	8.546:1	97,252	4.270:1	5.325:1
Sub-total (4)	413,092	6.936:1	8.625:1	255,152	4.284:1	5.328:1
Total (1) and (2)	2,406,995	---	---	1,526,658	---	---
Total (2) and (3)	2,090,984	5.641:1	---	1,321,220	3.564:1	---
Total (1), (2) and (3)	2,695,112	---	---	1,701,150	---	---

BENEFITS AND COSTS - MIDDLE FORK OF FEATHER RIVER

Estimates of the "build-up" of recreation use of the Middle Fork area were made using constants developed from the more detailed reservoir studies without additional water development. A minimum of 225,000 annual visitor-day use and probably 337,000 visitor-day use would be generated by camping and picnicking facilities by the end of the 50-year pay-out period (1960-2010). Staged development of 980 camp and picnic units would be required to meet the probable annual use. Minimum annual use of all facilities by year 2010 is expected to be 319,000 visitor-days and probable use 475,000 visitor-days. Total annual visitor-day use accumulating over the fifty-year pay-out period (1960-2010) without additional water development are as follows:

	probable use	minimum use
Camping and picnicking	8,750,000	5,820,000
All Recreation Use	12,270,000	8,370,000

Net increases in cumulative total annual visitor-day use resulting from additional State water development over no additional water development from Turntable Dam to Oroville Reservoir, and for the Meadow Valley Plan were prepared for the fifty-year pay-out period (1961-2010) and are shown in Table 42. Net increases in cumulative total annual visitor-day use resulting from the Richvale Irrigation District water development over no additional water development for the fifty-year pay-out period (1961-2010) are shown in Table 43.

[illegible] NET INCREASES IN CUMULATIVE TOTAL ANNUAL VISITOR-DAYS USE FOR THE FIFTY-YEAR PAYOUT PERIOD (1961-2010) RESULTING FROM ADDITIONAL STATE WATER DEVELOPMENT FOR THE MIDDLE FORK AREA AND MEADOW VALLEY PLAN

	Visitor-days Use	
	Probable	Minimum
Public recreation - camp and picnic:		
Middle Fork-Turntable Dam to Oroville	4,714,380	3,435,750
Turntable Reservoir	3,286,820	2,220,850
sub-total Sloat to Oroville	8,001,200	5,656,600
Meadow Valley Reservoir	6,578,260	4,444,750
Total public recreation	14,579,460	10,101,350
All recreation uses - public and private:		
Middle Fork-Turntable Dam to Oroville	16,906,000	10,663,800
Turntable Reservoir	7,409,900	4,513,650
sub-total Sloat to Oroville	24,315,900	15,187,450
Meadow Valley Reservoir	15,706,100	9,893,350
Total all recreation uses	40,022,000	25,070,800

TABLE 43. NET INCREASES IN CUMULATIVE TOTAL ANNUAL VISITOR-DAYS USE FOR THE FIFTY-YEAR PAYOUT PERIOD (1961-2010) RESULTING FROM RICHVALE IRRIGATION DISTRICT DEVELOPMENT

	Probable	Minimum
Public Recreation - camp and picnic:		
Middle Fork-Nelson Point Dam to Oroville	3,559,600	2,483,750
Nelson Point Reservoir	3,631,200	2,453,500
sub-total Sloat to Oroville	7,190,800	4,937,250
Clio Reservoir	2,162,600	1,453,500
Total public recreation	9,353,400	6,397,200
All Recreation Uses - public and private:		
Middle Fork-Nelson Point Dam to Oroville	14,120,180	9,050,500
Nelson Point Reservoir	8,614,840	5,297,500
sub-total Sloat to Oroville	22,735,020	14,348,000
Clio Reservoir	5,328,360	3,322,050
Total all recreation uses	28,053,400	17,670,050

Net benefits and costs resulting from additional water development of the Middle Fork of the Feather River were estimated for both the Meadow Valley Plan and the alternate Richvale Plan. These minimum and probable benefits and 1956 and 1958 costs are shown for the fifty-year pay-out period as cumulative totals not adjusted to present worth. Annual operation, maintenance and replacement costs were estimated, using ratios developed from the reservoir studies. Table 44 shows these benefits and costs.

Comparison of the benefits and costs of both plans discloses that the Meadow Valley Plan is more economically feasible because the benefit-cost ratios for all combinations of probable and minimum benefits to 1958 and 1956 costs are higher than those for the Richvale Plan.

In terms of public recreation benefits, the Meadow Valley Plan would have 56% greater probable benefit than the Richvale Plan and 58% greater minimum benefit. Total probable and minimum recreation benefits from the Meadow Valley Plan would be 43% and 42% greater than that obtained from the Richvale Plan. However, public recreation costs are greater for the Meadow Valley Plan. Examination of the economic feasibility of Meadow Valley Plan and Richvale Plan discloses an advantage of from 18% to 20% for Meadow Valley Plan over Richvale Plan for the various combinations of resulting benefit-cost ratios.

44. NET CUMULATIVE TOTAL BENEFITS AND COSTS FOR THE MIDDLE FORK OF FEATHER RIVER RECREATION DEVELOPMENT FOR THE FIFTY-YEAR PAYOUT PERIOD, 1961-2010*

	Public Benefits		Costs		Total Benefits	
	Probable	Minimum	1958	1956	Probable	Minimum
Meadow Valley Plan						
Middle Fork-Turntable Dam to Oroville Reservoir	$ 9,428,760	$ 6,871,500	$ 5,654,800	$ 4,339,100	$33,812,000	$21,327,600
Turntable Reservoir	6,573,640	4,441,710	1,913,049	1,549,400	14,819,800	9,027,600
sub-total Sloat to Oroville Reservoir	16,002,400	11,313,210	7,567,849	5,888,500	48,631,800	30,355,200
Meadow Valley Reservoir	13,156,520	8,889,500	3,707,149	2,997,298	31,412,200	19,786,700
Total	29,158,920	20,202,710	11,274,998	8,865,798	80,044,000	50,141,600
Benefit-Cost Ratios:						
1958 costs	2.586:1	1.792:1	---	---	7.099:1	4.447:1
1956 costs	3.281:1	2.279:1	---	---	9.028:1	5.655:1
Richvale Plan						
Middle Fork-Nelson Point to Oroville Reservoir	7,119,200	4,967,500	4,922,800	3,777,400	28,240,360	18,101,000
Nelson Point Reservoir	7,262,400	4,907,000	2,277,174	1,839,319	17,279,680	10,595,000
sub-total Sloat to Oroville Reservoir	14,381,600	9,874,500	7,199,974	5,616,719	45,520,040	28,696,000
Clio Reservoir	4,323,200	2,919,900	1,398,051	1,124,677	10,676,720	6,644,100
Total	18,706,800	12,794,400	8,598,025	6,741,396	56,126,760	35,340,100
Benefit-Cost Ratios:						
1958 Costs	2.176:1	1.488:1	---	---	6.528:1	4.110:1
1956 Costs	2.775:1	1.898:1	---	---	8.325:1	5.242:1

*Not adjusted to present worth

PART VII. ULTIMATE RECREATION USE OF THE UPPER FEATHER RIVER SERVICE AREA

Many of the existing recreation areas in the Upper Feather River Basin and the which together constitute the Service Area, can safely absorb higher densities and increased recreation use. There are also several presently undeveloped recreation areas which will be utilized irrespective of water development as the pressure for new outdoor recreation areas increases throughout the state and nation.

General recreation areas are shown on Plate XII General Recreation Areas Upper Feather River Service Area Without Additional Water Development. The percentages of general land uses shown on the plan at ultimate development are as follows:

Total Service Area	100.0 percent
Agricultural areas	16.7
Water areas	1.5
General recreation areas	81.8
undeveloped areas	78.7
developable areas	3.1

Almost one-half of the ultimate recreation use in the Upper Feather River Service Area is expected to occur in river and stream areas. Camping and picnicking facilities would have about 50 percent of the probable ultimate 44,211,000 annual visitor-days use of developable facilities, followed by summer homes - 23.6 percent, resorts - 22.1 percent and organization camps - 7.1 percent.

Probable annual visitor-day use in the Upper Feather River Service Area without additional water development by ten-year periods from 1956 to 2050 is shown in Table 45. Probable annual visitor-days use and number of units by recreation facility is also shown by ten-year periods in Table 46. Tables A-7 through A-22 in the Appendix contain detailed figures for each hydrographic area by general recreation classification and type of recreation use.

45. PROBABLE ANNUAL VISITOR-DAYS USE IN THE UPPER FEATHER RIVER SERVICE AREA WITHOUT ADDITIONAL WATER DEVELOPMENT, 1956-2050

Year	Total Visitor-days in thousands	Total Visitor-days less highway users in thousands	Total Visitor-days for developable facilities in thousands
1956	3,199	2,060	1,545
1960	6,000	4,200	2,800
1961	6,800	4,700	3,190
1970	15,800	10,400	5,600
1980	26,300	17,500	9,240
1990	38,000	25,600	14,030
2000	50,500	34,200	19,100
2010	64,000	43,200	25,000
2020	77,500	52,800	31,000
2030	90,500	62,300	36,440
2040	104,000	70,000	40,840
2050	114,453	76,226	44,211

46. PROBABLE ANNUAL VISITOR-DAYS USE AND NUMBER OF UNITS BY TYPE OF RECREATION FACILITY IN THE UPPER FEATHER RIVER SERVICE AREA WITHOUT ADDITIONAL WATER DEVELOPMENT, 1956-2050

	Probable Visitor-days Use in thousands				Number of Units			
Year	Camp & Picnic	Org. Camps	Resorts	Summer Homes	Camp & Picnic	Org, Camps	Resorts	Summer Homes
1956	735.7	94.8	480.9	233.5	1,223	329	1,271	1,040
1960	1,356	176	750	500	3,980	628	2,060	2,780
1961	1,500	190	820	560	4,420	680	2,260	3,110
1970	2,420	400	1,560	1,120	7,120	1,430	4,280	6,230
1980	4,500	690	2,180	1,950	13,220	2,460	6,010	10,800
1990	6,660	970	3,600	2,800	19,600	3,460	9,920	15,560
2000	9,200	1,300	4,750	3,850	27,020	4,640	13,100	21,200
2010	12,370	1,660	5,970	5,000	36,440	5,930	16,500	27,800
2020	15,690	1,960	7,200	6,150	46,200	7,000	19,800	34,100
2030	18,400	2,300	8,490	7,250	54.100	8,220	23,400	40,300
2040	20,500	2,600	9,540	8,200	60,300	9,290	26,300	45,500
2050	22,134	2,783	10,398	8,896	65,100	9,940	28,640	49,420

ULTIMATE USE WITHOUT WATER DEVELOPMENT

Some 66.3 thousand acres of the total 1,934,600 acres in the Upper Feather River Basin (Hydrographic Areas Nos. 42-46) can be developed for recreation without additional water development. This area will be adequate for construction of over 124,600 units of all kinds with a total daily capacity of 498,640 people. These facilities could safely accommodate some 35,984,000 annual visitor-days use at ultimate development, and this use will generate additional use of 26,057,000 and 31,021,000 annual visitor-days in the form of other forest areas and highway users, respectively.

Average gross densities would be roughly 1956 densities. The average net density for the Upper Basin would increase from 6.5 to 7.5 capacity people per developed acre. Roughly 25 times more land would be developed compared to the present 2,603 acres.

Of the total 114,453,000 potential annual visitor-days use of the Service Area, about 93,062,000 would be in the Upper Basin which equals about 81 percent of the 132,000,000 total visitor-days forecasted in Part II. Total visitor-days less highway users would be 62,041,000 ultimately, or less than 61 percent of the 102,000,000 visitor-days forecasted for the Upper Basin.

Without additional water development, therefore, recreation demand, excluding highway users, would exceed safe use by more than 64 percent, and the facilities provided would be overcrowded to that extent to satisfy the demand. Such overcrowding would be a serious threat to the watershed and timber producing abilities and recreation attraction of the Basin and might further limit its continued use as a recreation area.

ULTIMATE USE WITH ADDITIONAL WATER DEVELOPMENT

The Plate, General Recreation Areas Upper Feather River Service Area With Additional Water Development, No. XIII, includes the development of the following State Water projects: (a) Authorized Oroville, Dixie Refuge, Abbey Bridge, Antelope Valley, Grizzly Valley and Frenchman Reservoirs; (b) Study areas of Squaw Queen, Sheep Camp, Turntable, Meadow Valley, Swayne and Humbug Valley Reservoirs; (c) development of Genesee Valley as a State Park.

Construction of the above State water projects would double the existing water surface acreage within the Service Area, and would provide a more even distribution of recreation attractions and opportunities for recreation use over the entire area. Additional downstream areas would be enhanced with controlled water releases compatible with good streamflow maintenance practices permitting increased recreation use of these downstream areas for fishing and general recreation activities.

The increase in water surface and improvement of streams would permit the ultimate development of an additional 50,300 acres for recreation use, bringing the total to 132,120 acres in the Upper Feather River Service Area. Some 231,900 units, or 78,800 more units, can be developed with state water development. The capacity would be increased 51 percent from 612,400 to 927,700 people per day.

Of the 2,151,700 acres in the Service Area about 5.1 percent would be developed for recreation with water development compared with 3.1 percent without water development. Existing and ultimate percentages of general land uses for the Upper Feather River Basin and the Service Area are shown by each use classification in Table A-23 of the Appendix.

The average density in the Service Area would be increased from 0.05 to 0.09 units per gross acre as a result of water development. The net density, however, would be reduced from 1.88 without additional water development to 1.75 units per developable acre because of a higher proportion of low-density facilities (summer homes and organization camps) are expected with state water development. Water development would permit development of more areas at an average lower density. Without additional water development there would be fewer areas of recreation attraction, and, therefore, more intensive development of the available areas would occur. Table A-24 in the appendix compares existing densities to ultimate densities with and without water development by hydrographic unit.

Probable ultimate annual visitor-days use of developable facilities would be increased 47 percent - from 44,211,000 to 65,116,000 with water development of the Service Area. The East Branch of the Feather River would receive a higher proportion of the total recreation use and would stand to gain the most from water development since six of the proposed water projects would be located within the area. With water development, the concentration of use shifts from River and Stream areas to Reservoir and Lake Areas. Ultimate recreation use and development for each hydrographic area by general recreation classification and type of recreation use are shown in Tables A-7 through A-22 in the Appendix. Present and ultimate percentages of use distribution by hydrographic area, type of recreation facility and general recreation classification are shown in Table A-25 of the Appendix.

Probable ultimate recreation use in the Upper Feather River Service Area with State water development is expected to reach 168.6 million annual visitor-days by the year 2050. Probable annual visitor-days and number of facilities by type of recreation facility and net increases resulting from State water development by ten year intervals are shown in Tables 47, 48 and 49 which follow.

47. PROBABLE ANNUAL VISITOR-DAYS USE IN THE UPPER FEATHER RIVER SERVICE AREA AND NET INCREASES RESULTING FROM STATE WATER DEVELOPMENT, 1956-2050

Year	Total Visitor-days Probable Use	Total Visitor-days Net Increase	Total Visitor-days less highway users Probable Use	Total Visitor-days less highway users Net Increase	Total Visitor-days for developable facilities Probable Use	Total Visitor-days for developable facilities Net Increase
1956	3,199	-	2,060	-	1,545	-
1960	7,500	1,500	4,900	700	2,868	68
1961	8,600	1,800	5,600	900	3,374	180
1970	21,000	5,200	14,200	3,000	7,526	1,926
1980	37,000	10,700	25,700	8,200	13,730	4,490
1990	55,000	17,000	38,000	12,400	21,210	7,180
2000	75,000	24,500	51,200	17,000	29,820	10,720
2010	94,000	30,000	65,400	22,200	38,210	13,210
2020	120,000	42,500	80,000	27,200	46,680	15,680
2030	144,000	53,500	93,100	30,800	54,670	18,230
2040	160,000	56,000	104,300	34,000	60,630	19,790
2050	168,576	54,100	112,272	36,000	65,116	20,905

48. ANNUAL VISITOR-DAYS USE AND NUMBER OF UNITS BY TYPE OF RECREATION FACILITY IN THE UPPER FEATHER RIVER SERVICE AREA WITH STATE WATER DEVELOPMENT, 1956-2050

	Probable Visitor-days Use in Thousands				Number of Units			
Year	Camp & Picnic	Org. Camps	Resorts	Summer Homes	Camp & Picnic	Org. Camps	Resorts	Summer Homes
1956	735.7	94.8	480.9	233.5	1,223	329	1,271	1,040
1960	1,360	190	786	550	4,000	636	2,170	3,060
1961	1,550	200	970	650	4,560	710	2,680	3,610
1970	3,400	486	2,000	1,640	10,000	1,740	5,520	9,110
1980	6,400	900	3,100	3,100	18,840	3,220	8,560	17,220
1990	10,000	1,470	4,900	4,840	29,400	5,250	13,520	26,890
2000	14,400	2,000	6,620	6,800	42,600	7,140	18,300	37,780
2010	18,300	2,540	8,430	8,940	53,800	9,070	23,270	49,670
2020	22,000	3,100	10,360	11,220	64,700	11,080	28,600	62,330
2030	26,000	3,650	12,000	13,020	76,500	13,020	33,150	72,330
2040	28,500	4,250	13,380	14,500	83,900	15,900	36,850	80,560
2050	30,787	4,606	14,383	15,340	90,550	16,450	39,710	85,220

49. NET INCREASES IN PROBABLE ANNUAL RECREATION VISITOR-DAYS USE AND RECREATION UNITS BY RECREATION FACILITY RESULTING FROM STATE WATER DEVELOPMENT IN THE UPPER FEATHER RIVER BASIN, 1960-2050

Year	Camp and Picnic Visitor-days (thousands)	Camp and Picnic Units	Organization Camps Visitor-days (thousands)	Organization Camps Units	Resorts, hotels, motels Visitor-days (thousands)	Resorts, hotels, motels Units	Summer homes Visitor-days (thousands)	Summer homes Units
1960	4	20	2	8	36	110	50	280
1961	50	140	10	30	150	420	90	500
1970	980	2,880	86	310	440	1,240	520	2,880
1980	1,900	5,620	210	760	920	2,550	1,150	6,420
1990	3,340	9,800	500	1,790	1,300	3,600	2,040	11,330
2000	5,200	15,580	700	2,500	1,870	5,200	2,950	16,580
2010	5,930	17,360	880	3,140	2,460	6,770	3,940	21,870
2020	6,310	18,500	1,140	4,080	3,160	8,800	5,070	28,230
2030	7,600	22,400	1,350	4,800	3,510	9,750	5,770	32,030
2040	8,000	23,600	1,650	5,890	3,840	10,550	6,300	35,060
2050	8,653	25,450	1,823	6,510	3,985	11,070	6,444	35,800

Considering only the Upper Feather River Basin (Hydrographic Areas 42-46), some 112,300 acres and 196,740 units could be developed with a daily capacity of 786,960 people. These facilities would generate 55,077,000 annual visitor-days at ultimate development, 39,883,000 in other forest areas and 47,481,000 visitor-days from highway users. The total use with water development of 142,441,000 annual visitor-days exceeds the forecasted total demand of 132 million. The potential ultimate 94,960,000 visitor-days less highway users is within 93 percent of the forecast of 102 million, and less than 11 percent overcrowding would occur to meet demand as opposed to 64 percent overcrowding without additional water development.

Construction of State water projects would permit the development of adequately safe, desirable, healthful recreation areas and facilities which would not require excessive overcrowding to meet demand. This would be consistent with the prime purpose of the basin and provide maximum enjoyment of the natural resources and the great outdoor recreation opportunities.

APPENDIX

PART VIII. MEASUREMENT OF RECREATION BENEFITS*

A summary of the method used in placing dollar values on recreation benefits related to five authorized projects in the Upper Feather River Basin was contained in Appendix A of Bulletin 59,[1] published in 1957. That method and the factors involved in its selection have been substantiated by additional study and utilized in the assessment of nine additional recreation areas discussed in this study. The details of the method and its rationality are presented in this section.

THE PROBLEM

Many attempts to place quantitative measures on recreation values have been made by the agencies involved, but without satisfying either the proponants of the method or the objections of affected interests. Following the publication of the summary review of recreation feasibility studies on five reservoirs in the Upper Feather River Basin, national interest on the problem was focused by public hearings conducted before a Senate Subcommittee of the Committee on Public Works,[2] and by the designation of the Army Corps of Engineers and the National Park Service of a dollar value for a per capita day visit to recreation areas related to water development projects. While national interest in quantitative measures on recreation values has been related to failure on the part of responsible agencies to anticipate full recreational potentials of reservoir projects, that of the State of California is related directly to the importance of utilizing waters of the areas of origin for the development of local natural resources.

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* Prepared in cooperation with Andrew H. Trice

1. State of California Department of Water Resources, Bulletin No. 59, "Investigation of Upper Feather River Basin Development", February, 1957.
2. See "Evaluation of Recreational Benefits from Reservoirs", Hearings Before a Subcommittee of the Committee on Public Works, United States Senate, (Washington, D.C., 1957); See also footnote no. 2 on page 42.

The reasons for not including recreation evaluations as an integral part of feasibility reports in the past have arisen because of the fundamental difficulty in appraising the dollar value of recreation. And, since it was either impossible or undesirable to charge for recreational use, even if dollar benefits were known, there has been no compelling reason to estimate them precisely. Where major multi-purpose projects have been undertaken, irrigation, power development, and other benefits, have far outweighed any estimates made of possible recreational value. Since these other benefits are more easily stated in dollars, and the beneficiaries more easily identified for purposes of collection, interest has focused upon non-recreation benefits. However, failure in the past to make adequate provision for recreational development in connection with projects justified on non-recreational bases and failure to undertake worthwhile projects where consideration of recreational values would have made a difference, underline the importance of evaluation which will make possible the placing of recreational values among those to be considered in project selections.

The assignment of dollar values to recreational benefits is of paramount importance in connection with authorized reservoirs under study in the Upper Feather River Basin. It is anticipated that a substantial part of the project values for several of the reservoirs will be recreational in nature. Without dollar values for recreational benefits, certain of the projects might not be economically feasible, since total costs might be greater than the total of non-recreational benefits. In addition, benefit-cost computations are needed which include recreational benefits and costs in dollars, so that ratios for Upper Feather River projects may be compared in dollar terms with other uses of State funds and so that priorities can be established for reservoir construction.

Primary and Secondary Benefits

Benefits from reservoir projects are of two kinds: primary and secondary. Primary benefits arise directly from the project itself; secondary benefits are those which follow the impact of primary benefits. An example of primary benefits are net benefits accruing to farmers from irrigation water supplied by reservoir projects. Secondary benefits are either induced by the primary benefits or stem from them. Illustrative of induced secondary benefits are those received by businesses which secure increased supplies of raw materials, or raw materials at a lower price; while secondary benefits stemming from the project include those accruing to the business community due to increased expenditures by the farmers receiving the primary benefit.[1]

According to the principles developed by the Federal Inter-Agency River Basin Committee in its report on Proposed Practices for the Economic Analysis of River Basin Projects, only primary recreational benefits are to be considered in connection with multipurpose projects. The same principle applies to non-recreational project benefits also and is not, therefore, a peculiarity of recreational benefits.[2] Although it cannot be said that there is unanimous agreement among analysts as to the desirability of focusing attention upon primary benefits alone, there is a very strong sentiment in that direction. It is believed that secondary benefits tend to overlap primary benefits with resulting double counting of benefits. Also, since many factors contribute to business growth and prosperity, there is danger that benefits of the

1. See Federal Inter-Agency River Basin Committee, Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects, (Washington; May 195?) pp. 7-11, 35-36, 39-40. See also S. V. Ciriacy-Wantrup, "Benefit-Cost Analyses and Public Resource Development", Journal of Farm Economics, Vol. XXXXXVII, No. 4, November 1955; and miscellaneous unpublished writings of Professor David Weeks, Giannini Foundation for Agricultural Economics, University of California.
2. Subcommittee on Benefits and Costs, op.cit., p. 11.

secondary type may be attributed to a project when they are really attributable to something else. When to the dangers of double counting and possible improper credit of benefits, there is added the very great difficulty of approximating secondary benefits and the widespread suspicion of such figures when they have been estimated, there appears to be ample grounds for avoiding the computation of secondary benefits wherever possible.

Professor Wantrup of the University of California clarifies the issue when he suggests that computation of primary benefits is sufficient where the problem is the selection of a project.[1] Only when repayment of costs is expected would Professor Wantrup resort to the computation of secondary benefits. If his line of reasoning is adopted, and it does appear to have practical value, only primary benefits need be considered in the present instance since project selection or justification is under consideration and direct repayment by recreationists or local business interests is not contemplated.[2]

The Nature of Primary Benefits

Primary benefits from recreation are intangible and, therefore, immeasurable in dollar terms. This fundamental tenet is concurred in by vitually all persons who have given the problem careful consideration.[3] On the basis of this major premise it would appear that attempts to place dollar values on recreation should be abandoned. As a matter of fact there are those who advocate this course of action not only because of the seeming impossibility of the task, but because it is their belief that even the most optimistic estimates will understate true recreational

1. Ciriacy-Wantrup, op.cit., p. 688.
2. Subcommittee on Benefits and Costs, op.cit., pp. 51-52.
3. Ibid., p. 51. Also, Land and Recreational Planning Division, National Park Service, The Economics of Public Recreation, Washington, D.C. 1949. The "Prewitt Report", p. 30; Kenneth Decker, Evaluation of Public Recreation (Sacramento: reproduced by State of California Recreation Commission, 1951) p. 1.

values, thus leading to their disparagement as compared with non-recreational values.[1] The United States Forest Service has refused, for example, to place dollar values on recreational use of the forests under its jurisdiction. The Forest Service has been able to live with this policy, it appears, only because it need not resort to dollar comparisons to justify its program.

If recreational benefits to the individual are intangible, how is it possible to express them in dollars? Very generally, the expression of intangible values in dollars call for the derivation of "judgment values".[2] The "Prewitt Report" of the National Park Service concluded that if the interests of the Park Service require intangible benefits be expressed in dollars, such dollar values were to be based upon the best judgment of those most competent to evaluate such intangibles. The Inter-Agency River Basin Committee recommended the simulation or estimation of at least minimum values for intangible benefits, valuing them "as if" they were products exchanged in the market place.[3] Over and above minimum values expressed as though exchanged in the market place, the Inter-Agency Committee recommended that residual intangible benefits or values which continued to defy evaluation in money terms should be described generally so that their existence and importance is not overlooked.

Specific recommendations in the Prewitt Report as to methods to employ in estimating market values include those of Professor Howard Ellis of the University of California and those of Professor Harold Hotelling of the University of North Carolina. Professor Ellis suggested that

1. National Park Service, op.cit. p. 6.
2. Ibid p. 30.
3. Ibid. p. 5. Although market values would be simulated, the values would actually lie outside the market and would be "extra market" in nature. See also "Evaluation of Recreational Benefits from Reservoirs, "Hearings Before a Subcommittee of the Committee on Public Works, United States Senate, (Washington, D.C.: 1957) pp. 119-123.

recreational benefits be derived by assuming dollar values in terms of what a monopolist would charge if he were to control the recreational area.[1] Professor Hotelling suggested that a study be made of distances travelled by those using the national parks to determine the cost of such travel and, by comparing costs incurred by those travelling the greatest distances, to determine the dollar saving of all those able to enjoy the parks without incurring the full travel expense of the most distant travellers.[2] Both of these suggestions involve the concept of a "consumer surplus" or a free value associated with payment of prices below what an individual would be willing to pay. An adaptation of Professor Hotellings' idea will be developed at a later point in connection with procedures for measurements of recreational value in the Upper Feather River Basin.

CURRENT METHODS OF VALUING RECREATION BENEFITS

Two principal methods of estimating dollar values for recreation have been used. One is based upon expenditures by users of recreation facilities, while the other is based upon costs of providing recreation facilities for their use in national parks or in connection with multipurpose reservoir developments.[3]

Expenditure Approach to Estimating Recreational Benefits

The expenditure approach assumes that dollars spent for recreation are appropriate measures of recreational benefit to those persons engaging in it. Results of sample studies of actual expenditures by recreationists of various types at different times and in different places are shown in

1. Ibid. p. 6. Something similar to what Professor Ellis suggests can be accomplished by the method proposed later in this study. The problem is to find a method for determining what a monopolist would charge if he were a mind reader as well as a monopolist.
2. Ibid. pp. 8-9.
3. Robert F. Wallace, An Evaluation of Wildlife Resources in the State of Washington, (Pullman, Washington, Bureau of Economic and Business Research, State College of Washington, February, 1956) pp. 1-5, for an explanation of one expenditure approach.

Table - A. According to these data average expenditures in continental United States ranged from a low of $3.89 per day in Kans in 1952 to $18.00 per day for steelhead anglers in California in 1953. An array of these average expenditure figures for the United States reveals that the greater number of per day visitor expenditures ranged from $6.00 to $10.00, with an interpolated median average of about $8.70. In California the most common figures ranged from $6.00 to $11.00 per visitor day. On the basis of these figures, it appears a representative gross expenditure for recreation in California lies somewhere between $8.00 and $9.00 per day.[1]

The expenditure approach is not a satisfactory method for measuring intangible values to the person enjoying recreation. In the first place, many so-called recreational expenditures are simply normal expenditures made under slightly different circumstances. For example, a substantial portion of food, clothing, and travel expenditures would have taken place in the absence of recreation, simply as a part of daily living. (See Plate - A). And, in the second place, even those expenditures which are over and above normal living costs are not necessarily measures of recreational enjoyment, but are the price paid for certain goods and services for which there are established market values. Dollars spent in pursuit of recreation appear to be more significant as indicators of secondary benefits to the business community than as measures of primary recreational benefits.[2] However, even when used as indicators of secondary benefits to the business community, recreational expenditures constitute gross or total dollars rather than the increase in net income to business. Their indiscriminate use as measures of

1. Actually the figures shown in Table - A, are not strictly comparable, since they involve in addition to different times, places, and recreational activities, differences in accounting procedures.
2. It would be possible and profitable to estimate the effect upon the business community of Plumas County of new dollars generated by increased recreational activities resulting from the proposed projects. For an excellent analysis of tourist expenditures and their effects upon an economy, see John Child and Company, The Impact of Visitor Dollars in Hawaii (Honolulu: Hawaii Visitors Bureau, March, 1953).

secondary benefit may tend, therefore, to give an inflated idea of their importance to the business community (See Plate - B). Gross recreational expenditures in this analysis are rejected as being inappropriate measures of either personal recreational enjoyment or community benefits of a secondary type.

Cost Approach to Estimating Recreational Benefits

The second method used for estimating recreational values is associated with multipurpose reservoir projects for the most part and may be described as the cost method. The most notable use of costs as a measure of recreational benefits is found in the computations of the Bureau of Reclamation. The Bureau staff customarily estimates costs of recreational developments and then assigns an equal amount to recreational benefits. In some instances, however, the Bureau uses benefit figures supplied it by the National Park Service.[1] The National Park Service has used costs also as the basis for determining benefits, although the benefits attributed to recreation by it are twice as large as the estimated costs. The reason for the difference is found in the National Park Service practice of considering primary benefits equal to costs and secondary benefits equal to primary benefits. Thus, recreational benefits are always twice as great as costs in their calculations.[2]

1. See Bureau of Reclamation, San Luis Unit, Central Valley Project (Sacramento; May 1955) pp. 115-124 and Bureau of Reclamation, Ventura River Project (Sacramento) p. 149. See also Alfred R. Golge, Reclamation in the United States (New York; McGraw-Hill Book Co., Inc., 1952), pp 127-128.
2. During the past year the National Park Service has developed a $1.60 per day value of recreation in National Parks. From explanations found in Park Service releases and in other references to it, the $1.60 appears to be based upon a study limited to expenditures by people engaging in recreation similar to that provided in National Parks. See August 1957, release of National Park Service entitled, A Method of Evaluating Recreation Benefits and Costs of Water Control Projects. See also the hearings of Subcommittee, on Public Works, loc, cit., and S. J. Dana, Problem Analysis Research in Forest Recreation (Washington, D. C.: Forest Service, United States Department of Agriculture, April 1957), p. 13.

The use of costs as a basis for estimating benefits involves circular reasoning. There appears to be nothing gained by assuming a constant relationship between benefits and costs. As must be obvious the reason for estimating benefits in the first place is to decide economic feasibility or, in other words, whether costs should be incurred at all. To assume that benefits are equal to, or twice as great as costs in every case, is to make every recreational project at least marginally feasible. In addition, to assume the ratio of benefits to costs is equal for every project removes the basis for establishing priorities among projects.

Even though the assignment of benefits on the basis of costs involves circular reasoning, it should be understood that recommendations as to recreational developments and, therefore, recreational costs, are based upon "value judgments" of persons qualified to appraise the need for and probable use of recreational facilities. Thus, recommendations as to recreation features are the result of careful analysis of all pertinent factors of accessibility, topography, probable development, population growth, and similar factors, it would appear reasonable to assume that the recreational features of the project would be worth at least what they cost or even twice what they cost. However, it appears that the cost method has not proven adequate in the past, since failure to plan recreational facilities in line with realized demand has been typical rather than exceptional in connection with projects completed where the cost method has been accepted practice.

METHOD USED IN THE UPPER FEATHER RIVER BASIN STUDY

Thus, no method currently in use for approximating recreational values is entirely acceptable. To a greater or lesser degree the dollar values cited, under both the expenditure and cost methods, must be rejected. <u>Not only must the popular current methods be rejected, but it is doubtful whether any completely satisfactory method can be discovered, since the values under consideration are primarily intangible.</u> It is against this background that the method developed in the pages which follow must be evaluated. In essence, a practical problem demands a practical solution, a solution which in the very nature of the case cannot be perfect.

For the method to be useful, it should provide a value which has the following general characteristics:

1. It is in terms of a standard unit of time and is expressed in dollars.

2. It is representative of recreational enjoyment for which there is no expenditure by the recreationists and for which the state is not directly reimbursed.

3. It is separately derived and independent of costs of providing recreation facilities.

4. It consists of a single figure which applies to recreationists in the Upper Feather River area as a group without regard to the form of recreation being enjoyed or to differences among individuals as to capacity to enjoy recreational benefits.

5. It should be peculiar to the area under consideration, even though similar areas may have similar values.

6. It should be reasonable in amount and subject to tests based upon judgment values by informed people.

The Nature of the Travel Cost Approach

The approach suggested by Professor Hotelling in his letter to the National Park Service most closely resembles that developed for this study. According to his method, an analysis of National Park patronage would be made to discover the points of origin or recreationists visiting a given park. Such recreationists would be grouped geographically into distance zones about the park. The average costs of travel to the park for each such group would be multiplied by the number of potential users within each zone. (See Plate - C). Those visiting the park from the most distant zone would set a bulk-line value of recreation provided by the park. A market value having been set it would be possible to compute the free value of recreation provided to those who do not have to travel so far. A total figure for free recreational value attributable to the park would be a summation of travel cost differences between the maximum or bulk-line and that for each zone, multiplied by the number of recreationists estimated to use the park from each zone.

In Professor Hotellings' approach, it is assumed that people enjoy parks to a similar if not identical extent. Therefore, if those visiting a park from the greatest distance pay for the privilege in travel expenses as much as $5.00, they have in effect established the value of recreation to everyone. Since all others who visit the park receive the same $5.00 of benefit, they receive recreation, in effect, at bargain rates. Thus, if it costs recreationists from the next farthest zone $4.00 on the average, each of them receives $1.00 of free benefit. Similarily, if it costs $3.00 from the next zone, there is a $2.00 free benefit, and so forth. To the extent the use of the park has been made possible by expenditure of funds by the government, the individual recreationist who does not pay the full price is subsidized by the general tax rolls. This same subsidization occurs in connection with multipurpose reservoirs, since those who pay for the water and power or who pay taxes without enjoying the recreational advantages are underwriting the recreation of those directly engaged in recreation activities.[1]

Costs of travel to and from a recreational area appear to offer the least objectional method of differentiating among recreationists. Using costs of travel alone avoids questions of economic ability, personal tastes and appetites, forms of recreation engaged in, and other factors difficult to analyze. It is recognized that food and lodging are the other major expenditures of recreationists. To assume a single figure per day for food or lodging eliminates differences among recreationists entirely and removes the basis for establishing a market value and an actual, average cost as visualized in the Hotelling travel cost approach. By contrast, if a fixed rate per mile of travel is assigned all recreational parties, differences such as those of

1. Taxes paid by some recreationists may be in proportion to their recreational enjoyment.

wealth or taste are eliminated, but certain differences remain, nevertheless. These latter differences arise from the fact that some recreationists travel a lesser distance than others, stay more days, or share expenses with more people and in consequence, pay out fewer dollars for travel than those who travel longer distances, stay for shorter periods, or travel with fewer people sharing costs. The assumption of a fixed cost per mile traveled has, therefore, the dual advantage of removing income differences and at the same time producing per visitor day differences in costs of enjoying a recreational area. It should be noted that recreational value exists for every recreational area with or without specific improvements. Thus, the proposed reservoirs in the Upper Feather River area will not create the differences in travel costs to the area, since such cost differences already exist, but they will make possible the use and enjoyment of the area by a larger number of persons than would be possible without the improvements.[1]

Specific Applications of the Adopted Method

Plumas County and the Upper Feather River area which it includes is in the Sierra Nevada mountains northeast from Sacramento. To determine the value of a recreational day in that area it is necessary to consider actual recreational use patterns for Plumas County and for other similar areas in the high Sierras. Fortunately, data with respect to recreational use of three areas in the Sierras have been secured. The California Department of Water Resources gathered information by interview in the Upper Feather River area in 1956, and the United States Fish and Wildlife Service collected similar data for two sections of the Truckee River in 1956. While the three areas are separated by several miles, and therefore, distinct from one another,

1. A complication which must be recognized in the Hotelling approach (and in the current analysis) is that arising from the vacationist who visits or uses more than one recreation area opposed to another. The problem is somewhat reduced where alternative areas tend to be near one another and have similar features. For example, travel to the Sierra Nevadas for recreation may be considered for some purposes as a single form or type of recreation. Also, the distance traveled by vacationists may indicate the extent of alternative recreation charged to a single trip. Cross country travelers are more apt to view several natural wonders than those traveling a few hundred miles within a single state.

they were all in the High Sierras and can be considered comparable. Moreover, the data, themselves, are comparable and contain as a minimum the following information:

1. Number of persons in each recreational party.
2. The city or county of origin of each party.
3. The number of days spent by each party in the area of recreation.
4. The number of days the party spent on its entire recreation trip.

By use of the four items of information listed above, there was computed for each of several hundred parties of recreationists an average cost of travel per visitor day. In making this computation, the distance traveled in going and returning from each area of recreation was assumed to be the same for every party orginating in any one county. The distance was based upon road milage from the county seat or center of population to the center of the area of recreation, with estimates based upon points of origin and destination. In line with the current practice of California agencies, the total travel cost was taken as 6.5 cents per mile in the basic computations.[1]

Travellers coming from the greater distances did not spend as many days in the area as they spent on the trip. The persons may be considered to have indulged in recreation along the way in other recreational areas. In fact, in some cases the period spent in the area was much shorter than the period spent on the trip, suggesting that alternative recreation areas were more important. Undoubtedly, it would not be proper to consider the entire trip as for the sole purpose of enjoying recreation in the subject area. Since data as to intent and as to other recreation enjoyed on the trip were not available, it was assumed that a proper charge of travel cost to the area under study would be the percentage of the total round trip spent in the recreational area. Thus, if eight days out of ten were spent in the subject area, eighty percent of the round trip cost would be charged to the party's recreational use of the area.

1. Studies undertaken by the California Department of Finance indicate that 6.5 cents per miles is average cost of operating state vehicles. It is assumed that average mileage per month is 1,000 miles. Since trips to and from Sierra Nevada recreation areas range from 1,200 miles down, the 6.5 cent figure is a minimum rather than a maximum.

The per visitor day cost of travel for each party was secured by dividing the visitor days in the area into the proportion of the round trip cost allocated to the days spent in the area. Thus, if four people spent seven days in the area, on a fourteen day vacation trip, fifty per-cent of the computed round trip cost would be divided by the total number of person days in the trip (28), to obtain the per visitor day cost of travel.

Cost per visitor day for travel by the 288 parties surveyed in the Upper Feather River area, when 6.5 cents per mile is used, ranged from $22.62 at the highest to $.09 at the lowest. (See Graph 5). Either figure is extreme and probably unrepresentative. If a bulk-line market value is established at the 90th percentile, such extremes at the top of the range are eliminated. In the Upper Feather River study the 90th percentile had a cost per man day of $3.14. If the median average travel cost is considered representative of actual travel cost, in this instance, $1.05, a free value of $2.09 per man day is secured for the specific area. Similar computa-tions for the two portions at the Truckee River for which data were collected result in figures of $2.08 and $2.01 per man day.

Table - B and Graph 5 have been prepared to illustrate the method employed above. In Table - B is presented data for the three studies under two headings each. In column 1 is found the per man day cost of travel to the areas by recreationists. Column 2 in each instance provides cumulative man days of recreation based upon the dollar cost of recreational travel. For example, 269 man days on the Truckee River between Lake Tahoe and Donner Creek cost the recreationists interviewed $4.14 or more per day for travel alone, while 2,679 man days cost $1.07 or more. In effect, a demand schedule is shown for each of the three areas. Graph 5 is a diagramic portrayal of data found in Table - B.

On the basis of the foregoing computation a table showing comparative recreational values has been prepared. In addition to the figures secured with 6.5 cents per mile, figures have been computed also for costs of from 5.0 cents to 7.5 cents. In summary, the three areas show a free value for a day of recreation in the Sierra Nevadas of approximately $2.00, when 6.5 cents is used. A composite value of $2.00 per visitor day appears representative for the Feather River - Plumas County area, and may be suitable for the entire Sierra Nevada area.[1]

COMPARATIVE TABLE - DIFFERENCE BETWEEN 90th AND 50th PERCENTILES

	Cents Per Mile					
	7.5	7.0	6.5	6.0	5.5	5.0
Feather River	$2.42	$2.26	$2.09	$1.94	$1.77	$1.61
Truckee (Donner to Verdi)	2.32	2.16	2.01	1.86	1.70	1.54
Truckee (Tahoe to Donner)	2.41	2.25	2.08	1.93	1.77	1.61

CONCLUSIONS

The $2.00 figure satisfies the six criteria stated at the outset. (1) It is expressed as so many dollars per visitor or use day, and can be compared therefore, with other dollar values connected with the proposed reservoirs. (2) It represents recreational enjoyment over and above actual expenditures, an enjoyment which the state provides without specific direct charge to the recreationists. (3) It is derived without regard to costs of providing the reservoirs or any specific recreational facilities. (4) It abstracts from differences in taste and/or wealth. (5) It is based upon data for the subject area and is, in a sense, peculiar to the area's recreational features. (6) It is reasonable in amount.

1. A field survey in Calaveras County the summer of 1958 provided data which, when analyzed in the same fashion, yielded a $2.23 per man day recreation value at 6.5 cents per travel mile.

The computations of possible dollar values of recreation which have been made, involve rather broad assumptions as to the sameness or homogeniety of the members of the group under study. Although the reasonableness of the figures just cited is not based entirely or even primarily upon such assumptions or even upon the adequacy of the samples from which the computations are made, it should be noted that assumptions at least as broad are used in projections by the Bureau of Reclamation of primary irrigation benefits; for in such projections it is assumed that the land to be irrigated will actually be planted, that the projected crops grown on the land will find a market, that the prices received for the crops will be at an adequate level, that associated costs will not be too high, and so forth.

The key factor in the choice of $2.00 per visitor day is its reasonableness. How reasonable is the proposed $2.00 per visitor day figure? In the first place the $2.00 amount may be compared with actual recreational expenditure figures. (See Table - A). It is obvious that $2.00 is only a fraction of the average amount actually expended by tourists and other recreationists. As was suggested earlier in the analysis, the median average of such expenditures in California was between $8.00 and $9.00. Thus, the $2.00 value attributed to that part of recreation use of reservoir areas for which no specific charge is made is only 20 to 25 percent as large as actual average outlays.

The reasonableness of the dollar value of recreation is also measured in terms of probable continuing benefits which result from a vacation in the mountainous reservoir areas. To the individual who is there for one week, the immediate and carryover enjoyment of the experience is probably worth as much as $14.00 to him, over and above his actual expenditures. To the family of four who spend a week in the area the values to the group are probably as much as $56.00, dollar values not attributable to actual money spent in travel, for food and lodging, and other expenses.

The $2.00 per visitor day of recreation benefit, therefore, has been utilized in economic evaluations of fourteen recreation areas studied in the Upper Feather Basin. In using it or in using figures derived by its use, care should be taken, of course, to avoid overlooking secondary values to the community and to the state. Statewide values need to be identified separately and described at least in terms of general benefits which are over and above purely personal enjoyment of those engaging in the recreation. Included would be such statewide values as improved mental and physical health of citizens, reduced juvenile delinquency, and similar values which tend to be reflected in lower costs for institutions of restraint and institutions for treatment of the state's citizens. Important to the area itself, in addition, are expenditures for goods and services which enhance the local economy and increase the tax base. These latter derived secondary benefits, while difficult to isolate, are susceptible of analysis and could be used as evidence of heightened economic activity in the area affected by the proposed reservoir developments.

TABLE - A

EXPENDITURES OF TOURISTS

	Average per day Expenditures	Source No.
(Hunters in United States (arith. av.) 1955	$ 5.52 per day	1/
(Fishermen in the U. S. (arith. av.) 1955	4.82 per day	1/
Recreationist in United States (1956)	6.00 per day	2/
Recreationist in Central Valley Area (1955)	6.00 per day	3/
Bass Angler)	9.00 per day	4/
Salmon Angler) 1953	16.00 per day	4/
Steelhead anglers)	18.00 per day	4/
Tourist day (Southern California Winter)	10.01 per day	5/
(1953) (Southern California Summer)	11.06 per day	5/
(Northern California)	9.96 per day	5/
Tourist (1938)	7.00 per day	6/
Hawaiian Tourist (one to 90 days)	28.00 per day	7/
(1953) (91 to 365 days)	10.30 per day	7/
(passing through)	18.50 per day	7/
Reservoir - day use	2.00 per day	8/
recreationist	6.00 per day	8/
hunter	30.00 per day	8/
Utah motoring tourist (1948)	10.53 per day	9/
Montana tourist (1955)	7.72 per day	10/
Texas tourist (1955)	7.53 per day	11/
Colorado resident (1953)	5.32 per day	12/
Non-Colorado tourist in Colorado (1953)	8.06 per day	12/
Colorado Tourist (1955)	6.90 per day	13/
Colorado 1954	8.03 per day	13/
California 1953	10.25 per day	13/
Utah 1954	9.70 per day	13/
Texas 1954	7.80 per day	13/
Wyoming 1953	7.15 per day	13/
South Dakota 1954	6.85 per day	13/
Montana 1954	6.66 per day	13/
Arizona 1953	6.26 per day	13/
Nevada 1952	6.14 per day	13/
New Mexico 1953	6.20 per day	13/
Oregon 1953	5.36 per day	13/
Washington 1952	5.25 per day	13/
Kansas 1952	3.89 per day	13/
Tennessee 1953-1954	6.00 per day	14/ and 15/

Sources:

1/ United States Department of the Interior, Fish and Wildlife Service, National Survey of Fishing and Hunting, 1955 (Washington, D. C.: U. S. Government Printing Office, 1956), p. 28.

2/ United States Department of the Interior, Bureau of Reclamation, Reclamation's Recreational Opportunities. (Washington, D. C.: Department of the Interior, June, 1956).

3/ Bureau of Reclamation, The Contribution of Irrigation and the Central Valley Project to the Economy of the Area and the Nation. (Washington, D. C.: U. S. Government Printing Office, 1956), p. 34.

4/ David E. Pelgen, "Economic Values of Striped Bass, Salmon, and Steelhead Sport Fishing in California." California Fish and Game, Vol. 41, No. 1. (January, 1955), pp. 5-17.

5/ Kenneth Decker, The Tourist Trade in California. (Berkeley, California: Bureau of Public Administration, March 1955), p. 16.

6/ James P. Pope, Recreation, Speech before the Florence, Alabama, Rotary Club, September 11, 1939.

7/ John Child and Company, The Impact of Visitor Dollars in Hawaii, 1953, (Honolulu: Hawaii Visitors Bureau, 1955).

8/ Unpublished figures found in Bureau of Reclamation files.

9/ Division of Highway Planning, Utah Tourist Study. (Salt Lake City: Utah State Road Commission, 1950), p. 7.

10/ Advertising Office, The Montana Tourist Survey, 1955. (Helena, Montana: Montana Highway Commission, 1956), pp. 4 and 5.

11/ Information and Statistics Division, On The 1955 Texas Tourist Industry. (Austin, Texas: Texas Highway Department, 1956).

12/ L. J. Crampon and F. W. Ellinghaus, 1953 Colorado Statewide Summer Tourist Survey. (Boulder, Colorado: The Bureau of Business Research, University of Colorado, December, 1953), p. 27.

13/ Bureau of Business Research, The Tourist and Colorado. (Boulder, Colorado: University of Colorado, February, 1956), pp. 37-38.

14/ Lewis C. Copeland and I. James Pikl, Estimating Tennessee's Tourist Business, Nashville, Temessee: Department of Conservation, 1954?), p. 6.

15/ Lewis C. Copeland, Tennessee Tourist Trade in 1954. (Nashville, Tennessee: Tennessee Department of Conservation, September, 1955), pp. 6-7.

PLATE - A

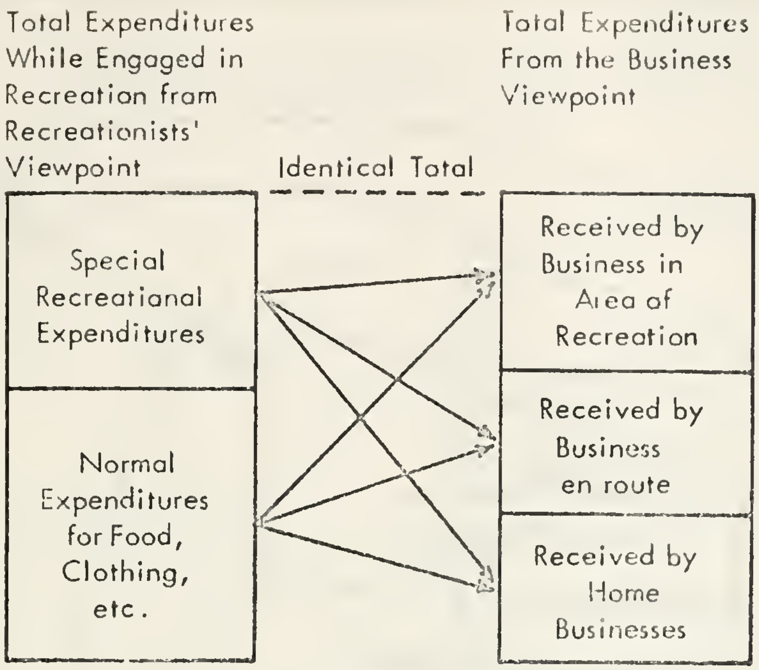


PLATE - B

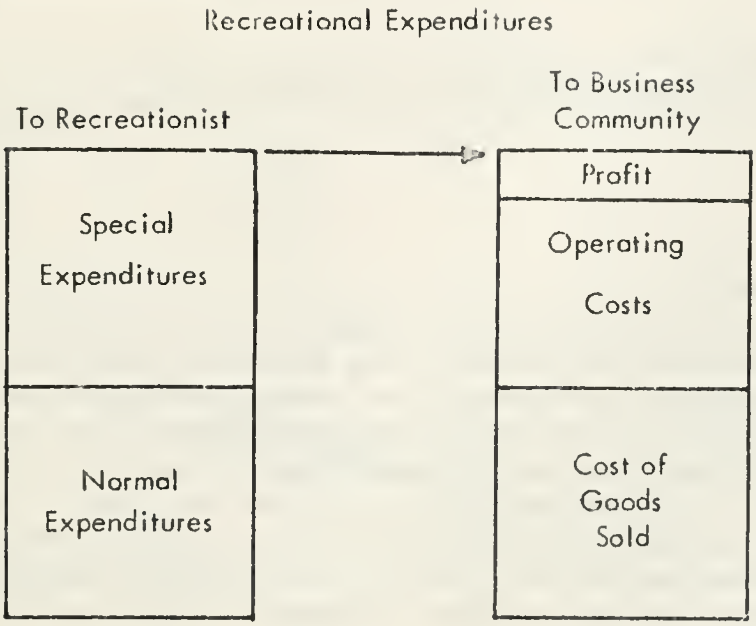
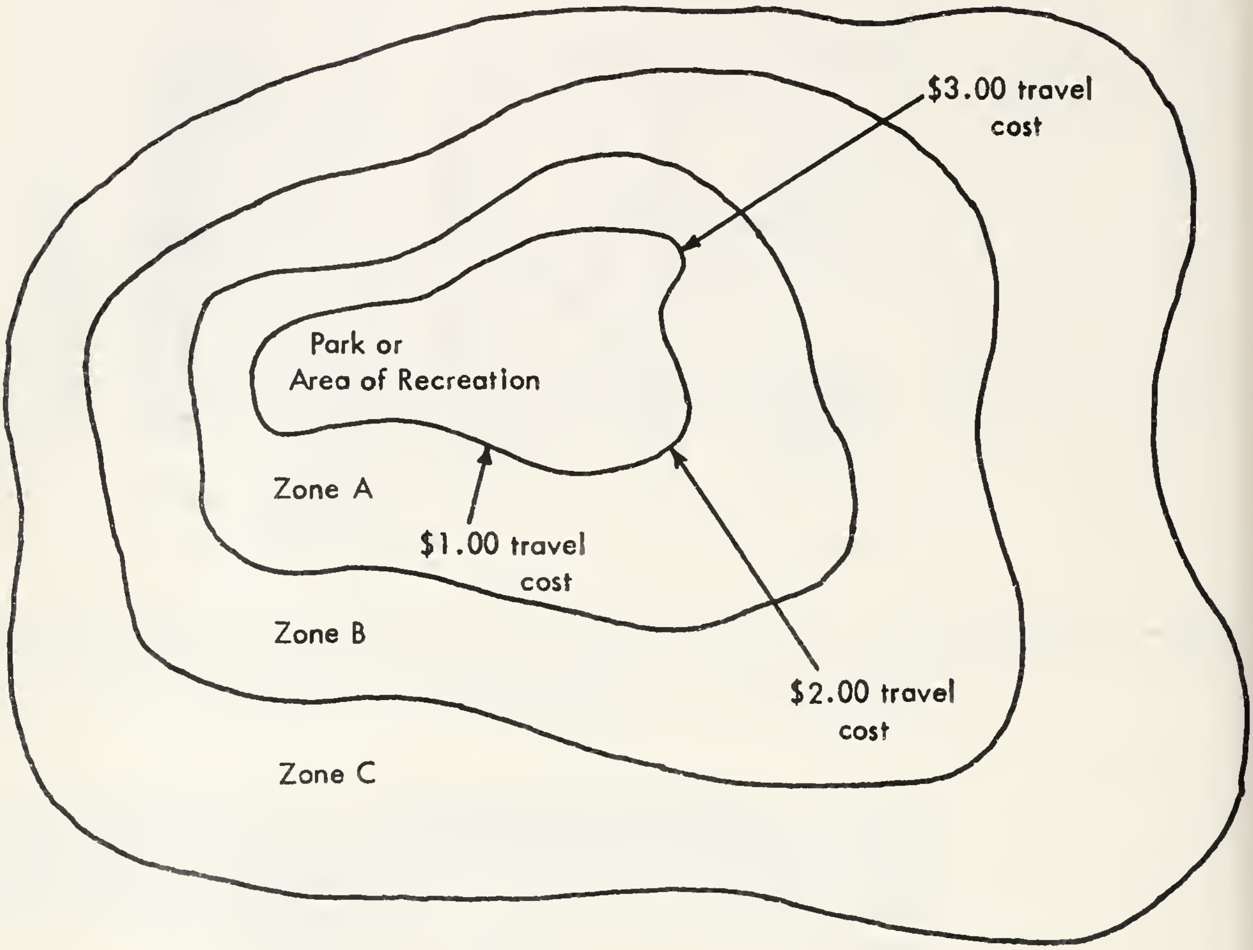


PLATE - C

Representation of Professor Harold Hotelling Concentric Travel Cost Zones *



* Explanatory note:

According to Professor Hotelling's suggestion, population around a national park (or recreational area) would be grouped in terms of average cost of travel to the park. Concentric circles or zones would include these groups. The consumer surplus of each zone would be determined by subtracting the average cost from the average cost of the most distant travel group or zone and then multiplying that figure by the number of persons in the zone likely to visit the park during any given period of time. For example, the highest travel cost is $3.00. The travel cost from Zone 1 is $1.00. Within Zone 1 there are 1,000,000 persons, ten percent of whom will visit the park during the given time period. The total consumer's surplus for Zone1 is therefore 100,000 times $2.00, or $200,000 for the time period.

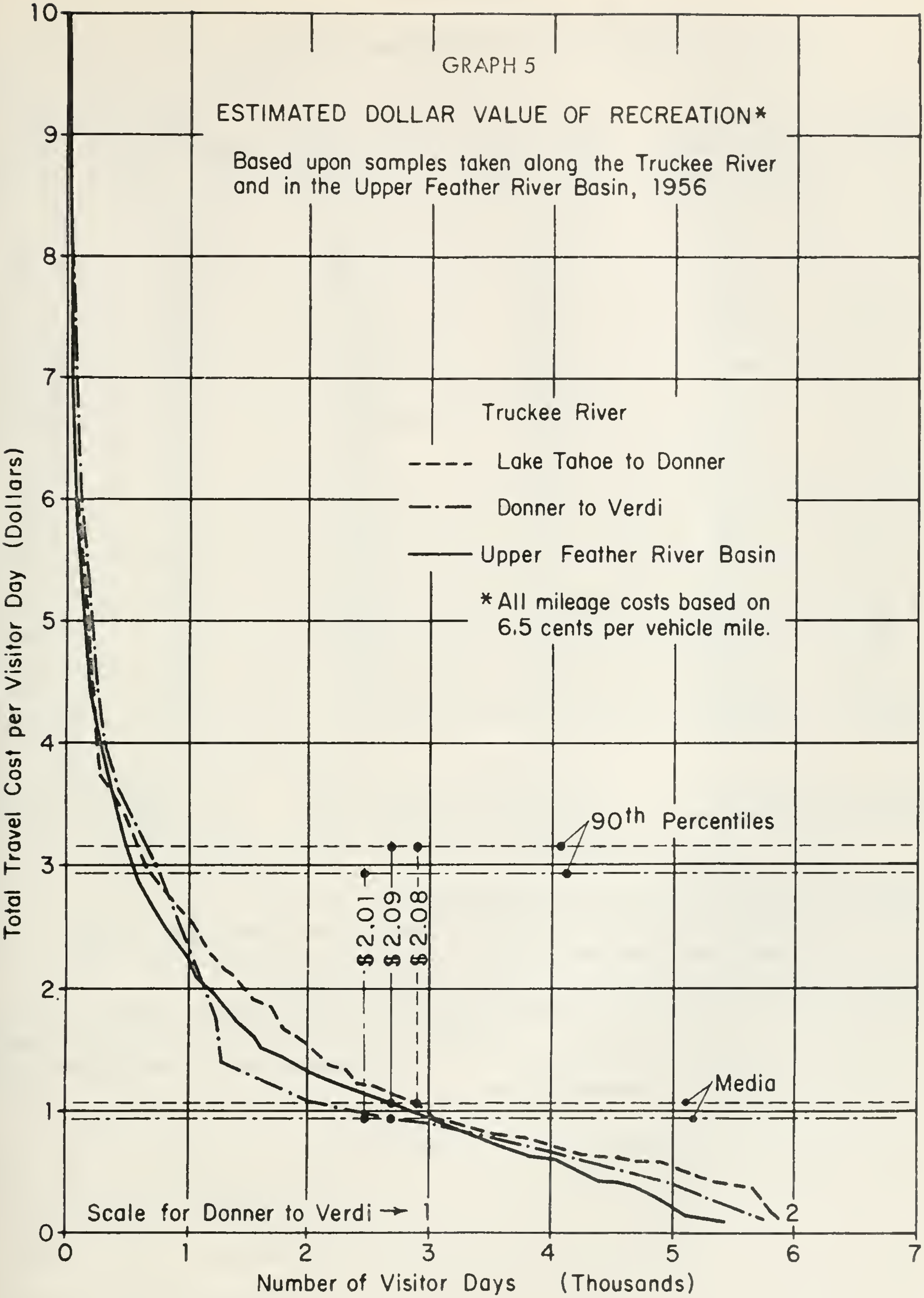

GRAPH 5
ESTIMATED DOLLAR VALUE OF RECREATION*
Based upon samples taken along the Truckee River and in the Upper Feather River Basin, 1956
Truckee River
Lake Tahoe to Donner
Donner to Verdi
Upper Feather River Basin
* All mileage costs based on 6.5 cents per vehicle mile.
90th Percentiles
$2.01
$2.09
$2.08
Media
Scale for Donner to Verdi → 1
2
Total Travel Cost per Visitor Day (Dollars)
Number of Visitor Days (Thousands)
0
1
2
3
4
5
6
7
8
9
10

TABLE - B

Estimated Dollar Value of Recreation[a]

Based upon samples taken along the Truckee River and in the Upper Feather River Basin, 1956[b]

	Lake Tahoe to Donner Creek		Donner Creek to Verdi Diversion		Upper Feather River	
	Travel Cost Per Man Day[c]	Cumulative Man Days[d]	Travel Cost Per Man Day[c]	Cumulative Man Days[d]	Travel Cost Per Man Day[c]	Cumulative Man Days[d]
1	$4.14	269	$4.33	99	$3.81	280
2	3.16	516	2.93	190	3.17	561
3	2.50	817	2.59	296	2.70	844
4	2.08	1,088	2.11	371	2.30	1,162
5	1.79	1,359	1.40	425	2.01	1,461
6	1.50	1,615	1.25	569	1.79	1,755
7	1.43	1,874	1.08	624	1.44	2,063
8	1.23	2,128	1.01	758	1.31	2,337
9	1.14	2,400	.94	874	1.19	2,621
10	1.07	2,679	.91	977	1.06	2,913
11	.92	2,991	.84	1,057	.86	3,253
12	.87	3,207	.78	1,092	.81	3,521
13	.72	3,478	.77	1,260	.75	3,790
14	.61	3,779	.68	1,331	.66	4,150
15	.55	4,037	.62	1,420	.64	4,316
16	.46	4,258	.59	1,520	.60	4,696
17	.36	4,593	.52	1,017	.52	4,955
18	.30	4,830	.39	1,671	.45	5,234
19	.13	5,047	-	-	.36	5,625
20	.08	5,367	.14	1,896	.09	5,839

$3.15 (90th percentile) minus
1.07 (50th percentile) equals
$2.08.

$2.93 (90th percentile) minus
.92 (50th percentile) equals
$2.01.

$3.14 (90th percentile) minus
1.05 (50th percentile) equals
$2.09.

(a) All mileage costs based on 6.5 cents per vehicle miles.

(b) Truckee studies by United States Fish and Wildlife Service; Upper Feather River Study by Department of Water Resources personnel.

(c) Computed per man day cost of getting to and from area of recreation.

(d) Although 100 or more different per man day costs of travel to and from the areas of recreation were computed, only twenty are shown in each case to reduce the size of the table. The twenty figures approximate but are not exactly at five point intervals since they are actual figures taken from the basic tables and not computed figures.

RECREATION RESOURCES AND POTENTIAL USE OF AUTHORIZED RESERVOIRS

Grizzly Valley Reservoir Area

Grizzly Valley is located in the east-central portion of the Upper Feather River Basin about six miles north of Portola. It is accessible by county road from Portola and Genesee Valley. The valley, at an elevation of 5,660 feet, is relatively flat and oblong oriented in a northwest-southeast direction. Although traversed by Big Grizzly Creek, most of the valley floor is dry with a moderate cover of native grasses. Scattered brush and some small trees cover the immediate slopes; and there are extensive stands of timber nearby.

The relative location of this reservoir assures the demand for, and use of, recreation development. Since it is only a few miles from U. S. Highway 40 Alternate, the major route through this area, it is within easy access to the thousands of recreationists using that route each year. Abbey Bridge, Squaw Queen, and Antelope Valley Reservoir Areas are located at four mile intervals north of Grizzly. These reservoirs form a chain of four, each one magnifying the attraction of the others.

The prime purpose of the reservoir is to furnish irrigation for Sierra Valley. Although the normal pool elevation of 5,775 feet will drop somewhat during the summer recreation season, this would not seriously affect recreation use. With some 4,100 acres of water surface at normal pool elevation, the reservoir will be approximately five miles long and one and one-half miles wide at its widest point.

The slopes surrounding the reservoir rise rapidly on the northeast side and gradually on the southwest side. The steeper slopes can be used for summer homes, while the more gradual slopes are most suitable for camp and picnic sites. Natural tree cover is close to the shoreline at the southeastern half of the reservoir. At the opposite end of the reservoir such cover exists from 1,000 to 3,000 feet from the shoreline. This restricts the development of campsites near the shoreline in this area until suitable cover is provided.

The plan for the Grizzly Reservoir area includes a balance of public and private recreation development. In general the eastern shoreline has been reserved for summer homes, which are located in most cases some distance from the water, with tree cover and a view of the lake and mountains beyond. These are on the high side of the access road and extend north and south close to the road. This provides easy access to the lake frontage and to the resort areas from each home site.

Resorts, motels and boat facilities have been located to provide these facilities on both sides of the lake. Two commercial centers have been suggested for the camp grounds on the southwestern slopes. One on the bluff southeast of the dam would be most intensively developed because of its central location, excellent view, relatively flat and forested ground and easy access to the major highway.

Camp sites are proposed on the southwest side of the reservoir because natural tree cover extends close to the shore line. The relatively flat land in this area contributes to the desirability of developing family and group camps. Some campsites are located at the northwestern end of the reservoir where the terrain and cover is suitable, though some distance from the shore.

As shown in Table 50, total probable use of the 1,797 units will be 474,180 annual visitor-days at ultimate development which is a 361,891 visitor-day net increase.

50. GRIZZLY VALLEY RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	154	766	3,064	352,360	176,180	260,750
Organizational Camps	76	95	381	43,800	21,900	26,720
Resort-Commercial	58	144	488	56,160	28,080	44,090
Summer Homes	792	792	3,169	142,620	71,310	142,620
Total	1,080	1,797	7,102	594,940	297,470	474,180

Antelope Valley Reservoir Area

Antelope Valley is located in the northeastern portion of the Upper Feather River Basin on Indian Creek, about one mile downstream from Boulder Creek Guard Station. This area can be reached by county road from Taylorsville in Indian Valley, a distance of about 20 miles. Taylorsville is about 10 miles northeast of U. S. Highway 40 Alternate via State Highway 89 and county roads. The valley is at an elevation of 4,900 feet and very irregular in shape, with surrounding slopes that are steep, somewhat rugged and well-forested.

This authorized reservoir is to be constructed for the purposes of recreation use and stream flow maintenance. The normal pool elevation will be 5,000 feet; and at this elevation the water surface will cover 930 acres. There would be a small drop in water elevation by the end of the summer recreation season with no adverse influence on recreation use. The reservoir will be about three miles in length and one mile wide at its widest point. The shoreline will be very irregular and contain the interesting physical effect of several peninsulas jutting into the water.

There is flat terrain suitable for beach and camping areas. The surrounding mountain slopes rise steadily from the relatively flat shoreline, though more sharply on the south than on the north shore. In most cases good tree cover extends to the shoreline. Although one of the most remote reservoirs proposed in the Upper Feather River Basin, Antelope Valley is not difficult to reach by road and should attract those recreationists seeking the seclusion of the more isolated locations. It is also the northernmost unit in the "chain" of four reservoirs.

The projected recreation development of the reservoir emphasizes the remoteness of the location, suggesting extensive family camping areas and organization camping sites. Camp sites were located on relatively flat wooded terrain with access to the lake. Proposed public beaches located on sandy slopes will provide good swimming conditions. A pack station has been located near the westerly end of the reservoir to accommodate parties into the Diamond Mountain country to the northeast.

The primary commercial and resort center has been located on the southerly shore to take advantage of convenient access to an existing county road. This location has a good view of the lake, with ample flat areas for necessary buildings and parking areas. Two small additional commercial areas have been suggested on the northerly side of the lake to provide for the needs of summer vacationists in that area.

Summer homes are scattered in small groups around the entire lake. The largest concentration of cabins has been proposed on the southerly shore, with public beaches along the water front. Two peninsulas on the north shore have been proposed for summer home development. In all cases the location of cabin sites has been based upon obtaining views of the lake and using steeper slopes which would be less desirable for camping.

51. ANTELOPE VALLEY RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp & Picnic	102	510	2,040	234,600	117,300	173,600
Organizational Camps	66	82	329	37,800	18,900	23,060
Resort-Commercial	22	56	225	25,920	12,960	20,350
Summer Homes	506	506	2,023	91,020	45,510	91,020
Total	696	1,154	4,617	389,340	194,670	308,030

Abbey Bridge Reservoir Area

The Abbey Bridge Reservoir area is located in Red Clover Valley in the central eastern portion of the Upper Feather River Basin. The dam site, approximately two miles above the Abbey Bridge Guard Station, is 14 miles by county road from U. S. Highway 40 Alternate via Beckwourth. The reservoir area is three miles north of Grizzly Valley Reservoir. It has a long narrow shape, extending approximately one and one-half miles into Red Clover Valley and ranging in width from 800 to 4,400 feet. Most of the land in the valley is used for dry pasture, and there are scattered brush areas and small trees along the slopes. The valley lies at an elevation of 5,350 feet, and is separated from Grizzly Valley by a mountain ridge.

The reservoir is to be constructed for recreation use and stream-flow maintenance. The normal pool elevation will be 5,420 feet, and the water surface area at this elevation will cover 540 acres. The reservoir would be about four miles long and one mile wide at its widest point.

Most of the slopes surrounding the shore of the reservoir rise rapidly. A relatively flat shelf about 300 to 400 feet wide at the shoreline is suitable for public beaches. At three locations along the southern shore the slope is gradual enough for camp and picnic areas. Tree cover extends close to the shoreline around the western half of the reservoir. Tree cover also exists at the opposite end of the reservoir but is some distance from the shoreline.

Summer homes are proposed on both the north and south shores, set back into tree-covered slopes to allow public use of the water frontage area. A major resort is located on the south shore of the lake near the dam site, because of accessibility and proximity to year around deep water. The relatively flat terrain of this location will provide easy construction and adequate parking and circulation. A second resort site has been reserved on the north side approximately at the middle of the lake to serve the camps and home sites which will develop. A perimeter access road will have to be provided in order to serve the north shore.

Camping areas have been placed to provide scenic views, good drainage, and to prevent pollution of the lake. The camp locations selected have good cover and are relatively flat for easy development and maintenance. Camp sites near the edge of the lake would be designed to blend with the forest and terrain. The greatest concentration of development is proposed around the westerly end of the reservoir, because it will be least affected by probable water fluctuation and has the best tree cover.

52. ABBEY BRIDGE RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use: Capacity	Minimum	Probable
Camp & Picnic	94	468	1,872	215,280	107,640	159,310
Organizational Camps	53	66	264	30,350	15,175	18,510
Resort-Commercial	28	70	282	32,400	16,200	25,430
Summer Homes	475	475	1,900	85,480	42,740	85,480
Total	650	1,079	4,318	363,510	181,755	288,730

Dixie Refuge Reservoir Area

Dixie Refuge Reservoir area is located in the northeastern corner of the Upper Feather River Basin approximately seven miles south of Milford and about 27 miles north of U. S. Highway 40 Alternate. It can be reached by county road from U. S. 40 Alternate via Beckwourth or Chilcoot, or from U. S. Highway 395 via Milford. The valley lies at an elevation of 5,600 feet and is relatively flat and covered with grasses. The immediate slopes are moderately covered with brush and scattered trees, and the surrounding mountains are well forested. When filled, the reservoir will roughly resemble an inverted "V". This reservoir area abuts the northern boundaries of Dixie Mountain Game Refuge.

The reservoir is to be constructed for recreation use and stream-flow maintenance. The normal pool elevation will be 5,740 feet, and the water surface area will cover 880 acres. The reservoir would be about three miles long and not quite a mile wide at its widest part.

The mountains on the northwest and southeast sides of the reservoir area are relatively steep while those to the northeast slope more gradually to the reservoir shore. The south shore has usable land for development and averages 900 feet in depth. The north shore has tree cover extending to the shoreline. The south shore has little or no tree cover within one-half to three-fourths mile of the shoreline, and little recreation development can be anticipated until necessary tree cover is available.

Two organizational camp sites have been proposed, one on the northeast shore close to the shoreline and another larger area near the dam site. A lodge and commercial area is planned for the upper northeast shore with summer home sites developed back from the shore. The entire northwest shore is planned for public camping and picnicking with summer homes on the north side of the access road on the steeper slopes. No recreational development has been planned for the southern shore until it can be reforested.

53. DIXIE REFUGE RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp and Picnic	70	350	1,400	161,000	80,500	119,140
Organizational Camps	44	55	220	25,350	12,675	15,460
Resort-Commercial	17	42	169	19,440	9,720	15,260
Summer Homes	354	354	1,415	63,660	31,830	63,660
Total	584	801	3,204	269,450	134,725	213,520

Frenchman Reservoir Area

Frenchman Reservoir area is located on Little Last Chance Creek in the far eastern portion of the Upper Feather River, Basin, about eight miles north of Chilcoot on U. S. Highway 40

Alternate. The accessibility of this area by automobile will encourage its use for recreation. It is the first reservoir encountered by those recreationists entering the Basin from the south or east via U. S. Highway 395.

The reservoir will store and release water for the irrigation of Sierra Valley, and provide flood control to downstream areas. The operation schedule would not interfere with recreation use except in the relatively few dry years when maximum draw-down would occur. In most years the anticipated draw-down of ten feet would not appreciably reduce the lake area or affect recreation use. The normal pool elevation will be 5,588 feet, and the water surface area will cover 1,525 acres. The reservoir will be over seven miles long and a mile wide at its widest point. There would be a "narrows" some 400 feet wide and 1,600 feet long at the middle of the reservoir splitting it into two sections.

On the east side of the reservoir, just north of the dam site, would be a large bay with good tree cover on its shores. The largest portion of the proposed development of the reservoir is concentrated around the southwest bay. Camping areas have been proposed on the westerly side of the reservoir because of the possibilities for a trail system into the higher mountains to the west. Some camp grounds and organized camps are proposed on the eastern side. A resort is suggested on an overlook at the east side of the "narrows". This location has a good view of the entire lake, some volcanic rock formations and a scattering of cover. Two other resort-commercial areas are proposed, one on the easterly end of the south bay and one close to the campsite. Extensive public beach areas are provided in conjunction with the summer home development and the resorts.

54. FRENCHMAN RESERVOIR AREA ULTIMATE RECREATION DEVELOPMENT, 2050

Recreation Facility	Acres	Number of Units	Visitors Per Day	Visitor-Days Annual Use Capacity	Minimum	Probable
Camp and Picnic	119	596	2,384	274,160	137,080	202,880
Organizational Camps	62	77	307	35,350	17,675	21,560
Resort-Commercial	38	94	376	43,200	21,600	33,910
Summer Homes	606	606	2,424	109,100	54,550	109,100
Total	825	1,373	5,491	461,810	230,905	367,450

CHECK SHEET
Existing Recreation Areas and Facilities

: County ____________
: Hydrographic Unit ____________
: Sub-Unit ____________
: Key Number ____________
: .. ..

1. Name of Facility ____________

2. Location ____________

3. Owned by ____________ Address ____________ Tel. No. ______

4. Leased by ____________ Address ____________ Tel. No. ______

5. Operated by ____________ Address ____________ Tel. No. ______

6. Type of Facility (Resort, Hotel, Motel, Camp, etc.) ____________

7. Gross Area ________ acres. 8. Developed area ____________ acres.

9. Number of Units (rooms, camp sites, etc.) ____________

10. Other recreation facilities available (list by type, acreage and number of units)

Type	Acres	No. of units

11. Number of persons that can be accommodated at one time (capacity) ____________

12. Length of season ____________ 13. Peak month ____________

14. Total number of Visitors for 1956 season ____________

15. Percentage of total visitors staying overnight in 1956 (in transit) ____________

16. Percentage of total visitors in 1956 that were families ____________

17. Average length of stay ____________ 18. Facility was used in 1956 at ___% of capacity

19. Number of employees for 1956: All year ____________ Seasonal ____________

20. Facility has existed for ____________ years.

A-1. POPULATION OF THE UNITED STATES 1900-1950 AND FORECASTS TO 2050

Year	Population
1900	75,994,575
1910	91,972,266
1920	105,710,620
1930	122,775,046
1940	131,669,275
April 1, 1950	151,132,000
July 1, 1955 a/	165,271,000 b/
July 1, 1956 a/	168,091,000 b/

Population Forecasts

	High	Mean	Low
July 1, 1960 c/	179,358,000	177,905,000	176,452,000
" " 1965 c/	193,346,000	189,818,500	186,291,000
" " 1970 c/	209,380,000	202,875,000	196,370,000
" " 1975 c/	228,463,000	217,685,000	206,907,000
" " 1980	239,000,000	227,000,000	215,000,000
" " 1990	270,000,000d/	250,500,000	231,000,000
" " 2000	300,000,000	272,500,000	245,000,000
" " 2010	330,000,000	293,750,000	257,500,000
" " 2020	360,000,000	314,500,000	269,000,000
" " 2030	390,000,000	335,000,000	280,000,000
" " 2040	420,000,000	355,000,000	290,000,000
" " 2050	450,000,000	375,000,000	300,000,000

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a/ Estimated by the Bureau of the Census, Current Population Reports, Series P-25, No. 141, August 10, 1956.

b/ Including armed forces overseas.

c/ High and low projections from Bureau of the Census, Current Population Reports, Series P-25, No. 123, October 20, 1955. Mean projections are the arithmetical means between the high and low projections and are not those of the Bureau of the Census.

d/ 1990 high projection by Parksons, Brinckerhoff, Hall and Macdonald.

A-2. POPULATION OF CALIFORNIA 1900-1950 AND FORECASTS TO 2050

Year	Population	Percent of United States
1900	1,485,053	1.95
1910	2,377,549	2.59
1920	3,426,861	3.24
1930	5,677,251	4.62
1940	6,907,387	5.25
April 1, 1950	10,586,223	7.00
July 1, 1955a/	13,035,000	7.89
July 1, 1956a/	13,600,000	8.09

Population Forecasts

	High	Mean	Low	Percent of United States High	Mean	Low
July 1, 1960b/	15,413,000	15,011,000	14,609,000	8.59	8.44	8.28
July 1, 1965b/	17,781,000	17,100,000	16,419,000	9.20	9.01	8.81
July 1, 1970	20,000,000c/	18,800,000	17,600,000	9.55	9.27	8.96
July 1, 1980	25,600,000	22,900,000	20,200,000	10.71	10.09	9.40
July 1, 1990	31,200,000c/	26,750,000	22,300,000c/	11.56	10.68	9.65
July 1, 2000	36,200,000	30,200,000	24,200,000	12.07	11.08	9.88
July 1, 2010	41,000,000	33,500,000	26,000,000	12.42	11.40	10.10
July 1, 2020	45,500,000	36,650,000	27,800,000	12.64	11.65	10.33
July 1, 2030	49,800,000	39,600,000	29,400,000	12.77	11.82	10.50
July 1, 2040	54,000,000	42,400,000	30,800,000	12.86	11.94	10.62
July 1, 2050	58,000,000	45,000,000	32,000,000	12.89	12.00	10.67

a/ From California's Population in 1956, State Department of Finance, July 1956.

b/ High and low projections are from Projected Population of California by Broad Age Groups, 1956-1966, State Department of Finance, September 1955.

c/ High projection for 1970 and the high and low projections for 1990 are those developed by Parsons, Brinckerhoff, Hall and Macdonald for their report, Regional Rapid Transit, to the San Francisco Bay Area Rapid Transit Commission, January 1956.

A-3. DISTRIBUTION OF VISITOR-DAY USE BY TYPE OF RECREATION USE, NATIONAL FOREST LANDS IN CALIFORNIA, 1941-1955

Type of Use	15 yr. Mean	1941	Percentages of visitor-day use distribution by years 1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
Total visitor-day use - 100 percent																
Highways, roads and water routes	31.3	20.0	16.9	15.7	12.8	9.9	31.0	38.5	34.4	33.4	33.3	28.4	32.6	34.8	37.6	44.6
Winter sports	3.1	4.0	4.9	2.0	1.1	1.1	2.0	1.9	4.4	2.6	2.7	2.8	3.6	3.2	3.6	4.2
Wilderness and other forest areas	17.0	22.4	30.8	24.8	37.4	26.0	20.5	19.7	11.5	10.4	12.1	12.4	13.7	14.0	13.7	12.5
Camp & picnic	25.1	32.2	24.5	26.0	17.3	22.4	20.7	21.3	25.1	28.9	30.5	25.7	28.2	27.5	26.3	21.9
Organization camps	5.9	4.2	5.1	4.7	5.6	9.6	8.1	4.5	5.4	6.5	6.5	6.5	6.6	6.1	4.8	4.5
Hotels and resorts	5.8	6.6	7.0	15.6	10.0	15.7	8.1	6.6	8.4	5.0	3.2	3.2	3.2	3.3	3.0	2.5
Summer homes	11.8	10.6	10.8	11.2	15.8	15.3	9.6	7.5	10.8	13.2	11.7	21.0	12.1	11.1	11.0	9.8
Total visitor-days less highways users - 100 percent																
Wilderness and other forest areas	24.7	28.0	37.1	29.5	42.9	28.7	29.6	32.0	17.6	15.7	18.1	17.3	20.3	21.4	21.9	22.5
Winter sports	4.4	5.0	5.8	2.3	1.3	1.3	2.8	3.1	6.7	3.8	4.0	3.9	5.4	4.8	5.8	7.6
Camp & picnic	36.6	40.2	29.5	30.8	19.8	24.9	30.0	34.6	38.3	43.3	45.8	35.9	41.8	42.2	42.2	39.6
Organization camps	8.6	5.3	6.1	5.6	6.4	10.7	11.8	7.3	8.1	9.8	9.8	9.1	9.8	9.4	7.6	8.1
Hotels and resorts	8.4	8.3	8.4	18.5	11.5	17.4	11.8	10.8	12.7	7.6	7.6	4.4	4.8	5.1	4.9	4.5
Summer homes	17.3	13.2	13.1	13.3	18.1	17.0	14.0	12.2	16.6	19.8	19.8	29.4	17.9	17.1	17.6	17.7
Indoor	25.7	21.5	21.5	31.8	29.6	34.4	25.8	23.0	29.3	27.4	27.4	33.8	22.7	22.2	22.5	22.2
Outdoor	65.7	73.2	72.4	62.6	64.0	54.9	62.4	69.7	62.6	62.8	67.9	57.1	67.5	68.4	69.9	69.7
Organizational	8.6	5.3	6.1	5.6	6.4	10.7	11.8	7.3	8.1	9.8	9.8	9.1	9.8	9.4	7.6	8.1

A-4. PERCENTAGE DISTRIBUTION OF VISITOR-DAY USE BY TYPE OF RECREATION USE, PLUMAS NATIONAL FOREST, 1946-1956, AND UPPER FEATHER RIVER BASIN, 1956

Recreation Use	11 yr. average	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	UFRB 1956
Total visitor-days use - 100 percent													
Highways, roads and water routes	43.2	21.6	36.6	34.5	35.4	38.2	35.8	47.6	39.5	50.9	47.6	47.7	35.6
Winter sports	0.1	0.2	0.01	0.03	0.07	0.04	0.05	0.2	0.2	0.1	0.07	0.03	0.04
Other forest areas	21.4	10.2	25.2	26.4	22.2	22.2	19.4	19.1	23.2	21.7	22.1	21.6	16.0
Camp & picnic	19.6	18.7	17.0	18.3	21.0	24.4	26.4	22.2	20.0	16.2	19.7	18.7	23.0
Organization camps	5.0	3.6	2.7	4.0	4.0	4.2	4.7	3.6	7.5	5.0	5.1	6.3	3.0
Hotels and resorts	8.4	40.0	15.3	14.1	14.7	7.6	10.1	4.9	7.4	4.6	3.9	4.0	15.0
Summer homes	2.3	5.7	3.1	2.6	2.6	3.3	3.5	2.4	2.2	1.5	1.5	1.6	7.3
Total visitor-days less highways, roads and water routes use - 100 percent													
Other forest areas	37.6	13.0	39.7	40.4	34.4	36.0	30.2	36.4	38.4	44.2	42.2	41.4	25.0
Winter sports	0.2	0.2	0.02	0.05	0.09	0.07	0.07	0.5	0.3	0.2	0.1	0.05	0.06
Camp & picnic	34.5	23.9	27.0	27.9	32.6	39.5	41.2	42.4	33.0	33.0	37.6	35.8	35.7
Organization camps	8.9	4.6	4.4	6.1	6.3	6.8	7.3	6.9	12.4	10.2	9.7	12.0	4.6
Hotels and resorts	14.8	51.1	24.1	21.6	22.7	12.4	15.8	9.3	12.2	9.4	7.4	7.6	23.3
Summer homes	4.0	7.2	4.8	3.9	3.9	5.2	5.4	4.7	3.7	3.0	3.0	3.1	11.3
Private	18.8	58.3	28.9	25.5	26.6	17.6	21.2	14.0	15.9	12.4	10.4	10.7	34.6
Public	72.3	37.1	66.8	68.4	67.1	75.6	71.5	79.3	71.7	77.4	79.9	77.3	60.8
Semi-public	8.9	4.6	4.4	6.1	6.3	6.8	7.3	7.9	12.4	10.2	9.7	12.0	23.3

A-5. RECREATION USE IN UPPER FEATHER RIVER BASIN BY HYDROGRAPHIC AREA, 1956

	Hydrographic Area					
	Total Upper Basin	42 North Fork	43 East Branch	44 Sierra Valley	45 Middle Fork	46 South Fork
Area in acres (total)	2,293,700	771,200	653,800	336,800	430,900	101,000
Water area (surface acres)	40,600	38,500	900	-	1,100	100
Developed area in acres (total	2,603	1,186	485	85	780	67
camp and picnic	559	392	87	2	70	8
organization camps	184	60	109	-	10	5
resorts, hotels, motels	820	154	99	13	550	4
summer homes	1,040	580	190	70	150	50
Number of Units (total	3,863	2,062	816	122	740	123
camp and picnic	1,223	936	170	10	99	8
organization camps	329	125	135	-	32	37
resorts, hotels, motels	1,271	421	321	42	459	28
summer homes	1,040	580	190	70	150	50
Capacity people (total)	16,947	9,685	3,145	496	3,036	585
camp and picnic	6,345	4,647	779	30	828	61
organization camps	1,320	500	540	-	130	150
resorts, hotels, motels	3,662	1,448	786	96	1,248	84
summer homes	5,620	3,090	1,040	370	830	280
Capacity visitor-days (total)	2,561,100	1,424,900	565,200	79,600	417,300	74,100
camp and picnic	1,112,900	779,900	196,900	10,900	114,200	11,000
organization camps	98,800	40,500	40,600	-	5,700	12,000
resorts, hotels, motels	842,700	326,300	234,200	35,000	222,000	25,200
summer homes	506,700	278,200	93,500	33,700	75,400	25,900
Visitor-days use (total)	1,544,900	863,700	340,000	38,700	265,200	37,300
camp and picnic	735,700	513,100	123,800	5,800	84,200	8,800
organization camps	94,800	38,100	39,500	-	5,600	11,600
resorts, hotels, motels	480,900	183,700	133,700	17,400	141,100	5,000
summer homes	233,500	128,800	43,000	15,500	34,300	11,900
Average length of season in days						
total	151.1	147.1	179.7	160.5	137.5	126.6
camp and picnic	175.4	167.8	252.8	365.0	137.9	180.3
organization camps	74.8	81.0	75.2	-	43.8	80.0
resorts, hotels, motels	230.1	225.3	298.0	365.0	177.9	300.0
summer homes	90.2	90.0	89.9	91.1	90.8	92.5
Percent use (total)	60.3	60.6	60.2	48.6	63.6	50.3
camp and picnic	66.1	65.8	62.9	53.2	73.7	80.0
organization camps	95.9	94.1	97.3	-	98.2	96.7
resorts, hotels, motels	57.1	56.3	57.1	49.7	63.5	19.8
summer homes	46.8	46.3	46.0	46.0	45.5	45.9

A-6. RECREATION USE INTENSITIES (USE FACTORS), ANNUAL VISITOR-DAYS USE AND NORMAL VISITOR-DAY CAPACITY BY TYPE OF RECREATION USE -- NATIONAL FORESTS IN CALIFORNIA, 1946, 1950, 1955, PLUMAS NATIONAL FOREST, 1950, 1955 AND UPPER FEATHER RIVER BASIN, 1956

Recreation Use	Use Factor			Annual Visitor-Days (thousands			Normal Capacity at one time (thousands)		
National Forests in California									
	1946	1950	1955	1946	1950	1955	1946	1950	1955
Camp and picnic	66.4	73.9	111.7	4,185	4,641	6,814	63.0	62.8	61.0
Organization camps	81.4	53.7	57.8	1,645	989	1,399	20.2	18.4	24.2
Hotels and resorts	140.0	64.9	90.4	1,640	480	768	11.8	64.9	90.4
Summer homes	47.6	35.8	58.9	1,947	1,779	3,056	40.9	49.7	51.9
Winter sports	5.0	5.1	14.3	395	406	1,302	79.6	79.9	90.9
All uses	69.3	57.0	82.7	9,417	7,889	12.037	135.9	138.3	145.6
Plumas National Forest and Upper Feather River Basin									
	P. N. F. 1950	P. N. F. 1955	UFRB 1956	P. N. F. 1950	P. N. F. 1955	UFRB 1956	P. N. F 1950	P. N. F 1955	UFRB 1956
Camp and picnic	42.7	144.2	115.9	83.45	280.30	735.7	1.956	1.944	6.35
Organization camps	102.7	76.0	71.8	14.38	72.20	94.8	0.140	0.950	1.32
Hotels and resorts	44.8	50.8	131.3	26.18	55.01	480.9	0.585	1.082	3.66
Summer homes	30.0	37.9	41.5	11.16	21.88	233.5	0.372	0.578	5.62
All uses	44.3	94.3	91.2	135.17	429.37	1,544.9	3.053	4.554	16.95

Source: U. S. Forest Service, Inventory of Existing Recreation Areas and Facilities and Annual Statistical Reports of Recreation Visits; California.
Region 5 and Plumas National Forest for years shown.
Pacific Planning and Research, Survey of Existing Recreation Areas and Facilities in the Upper Feather River Basin: 1956

A-7. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT – 2050
Hydrographic Area No. 42 – North Fork Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	693,300	186,400	170,600	219,100	58,500	4,700	7,500*
developable area	37,300	420	5,970	15,340	14,630	940	50*
camp and picnic	5,170	420	900	2,300	1,460	90	-
organizational	3,970	-	660	1,690	1,620	-	-
resorts	4,580	-	1,130	2,150	1,020	280	50*
summer homes	23,580	-	3,280	9,200	10,530	579	-
No. of units (total)	65,840	2,100	11,440	28,180	22,400	1,720	130*
camp and picnic	25,850	2,100	4,500	11,500	7,300	450	-
organizational	4,960	-	830	2,110	2,020	-	-
resorts	11,450	-	2,830	5,370	2,550	700	130*
summer homes	23,580	-	3,280	9,200	10,530	570	-
Capacity people (total)	263,360	8,400	45,760	112,720	89,600	6,880	200*
camp and picnic	103,400						
organizational	19,840						
resorts	45,800						
summer homes	94,320						
Capacity visitor days	30,350,500	966,000	5,262,400	12,962,800	10,304,000	791,200	64,000
camp and picnic	11,891,000						-
organizational	2,281,600						-
resorts	5,331,000						64,000
summer homes	10,846,800						-
Average annual visitor days – probable use							
total	18,565,000	714,000	3,371,600	8,090,000	5,861,000	507,600	20,800
camp and picnic	8,789,000	714,000	1,530,000	3,910,000	2,482,000	153,000	-
organizational	1,388,800	-	232,400	590,800	565,600	-	-
resorts	4,142,800	-	1,018,800	1,933,200	918,000	242,000	20,800
summer homes	4,244,400	-	590,400	1,656,000	1,895,400	102,600	-
Average annual visitor days – minimum use							
total	11,855,000	483,000	2,172,000	5,193,400	3,677,800	315,800	13,000
camp and picnic	5,945,500	483,000	1,035,000	2,645,000	1,679,000	103,500	-
organizational	1,140,800	-	190,900	485,300	464,600	-	-
resorts	2,646,500	-	650,900	1,235,100	586,500	161,000	13,000
summer homes	2,122,200	-	295,200	828,000	947,700	51,300	-

* Not included in total

A-8. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050

Hydrographic Area No. 43 - East Branch Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	589,000	480,000	26,800	73,700	6,100	2,400	11,400*
developable area	9,180	1,080	940	5,160	1,520	480	70*
camp and picnic	2,190	1,080	140	770	150	50	-
organizational	840	-	100	570	170	-	-
resorts	1,150	-	180	720	110	140	70*
summer homes	5,000	-	520	3,100	1,090	290	-
No. of units (total)	19,880	5,400	1,800	9,460	2,330	890	180*
camp and picnic	10,950	5,400	700	3,850	750	250	-
organizational	1,050	-	130	710	210	-	-
resorts	2,880	-	450	1,800	280	350	180*
summer homes	5,000	-	520	3,100	1,090	290	-
Capacity people (total)	79,520	21,600	7,200	37,840	9,320	3,560	720*
camp and picnic	43,800						-
organizational	4,200						-
resorts	11,520						720*
summer homes	20,000						-
Capacity visitor days	9,202,400	2,484,000	828,000	4,351,600	1,071,800	409,300	57,600
camp and picnic	5,037,000						-
organizational	483,000						-
resorts	1,382,400						57,600
summer homes	2,300,000						-
Average annual visitor days - probable use							
total	5,982,600	1,836,000	530,000	2,713,800	610,800	263,200	28,800
camp and picnic	3,723,000	1,836,000	238,000	1,309,000	255,000	85,000	-
organizational	294,000	-	36,400	198,800	58,800	-	-
resorts	1,065,600	-	162,000	648,000	100,800	126,000	28,800
summer homes	900,000	-	93,600	558,000	196,200	52,200	-
Average annual visitor days - minimum use							
total	3,890,400	1,242,000	341,200	1,741,800	383,300	164,100	18,000
camp and picnic	2,518,500	1,242,000	161,000	885,500	172,500	57,500	-
organizational	241,500	-	29,900	163,300	48,300	-	-
resorts	680,400	-	103,500	414,000	64,400	80,500	18,000
summer homes	450,000	-	46,800	279,000	98,100	26,100	-

* Not included in total

A-9. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050
Hydrographic Area No. 44 - Sierra Valley

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban
Area in acres (total)	201,700	183,900	6,600	8,400	-	2,800
developable area	1,790	410	230	590	-	560
camp and picnic	590	410	30	90	-	60
organizational	100	-	30	70	-	-
resorts	290	-	40	80	-	170
summer homes	810	-	130	350	-	330
No of units (total	4,620	2,050	420	1,090	-	1,060
camp and picnic	2,950	2,050	150	450	-	300
organizational	130	-	40	90	-	-
resorts	730	-	100	200	-	430
summer homes	810	-	130	350	-	330
Capacity people (total)	18,480	8,200	1,680	4,360	-	4,240
camp and picnic	11,800					
organizational	520					
resorts	2,920					
summer homes	3,240					
Capacity visitor days	2,125,200	943,000	193,200	501,400	-	487,600
camp and picnic	1,357,000					
organizational	59,800					
resorts	335,800					
summer homes	372,600					
Average annual visitor days - probable use						
total	1,448,000	697,000	121,600	313,200	-	316,200
camp and picnic	1,003,000	697,000	51,000	153,000	-	102,000
organizational	36,400	-	11,200	25,200	-	-
resorts	262,800	-	36,000	72,000	-	154,800
summer homes	145,800	-	23,400	63,000	-	59,400
Average annual visitor days - minimum use						
total	949,200	471,500	78,400	201,700	-	197,600
camp and picnic	678,500	471,500	34,500	103,500	-	69,000
organizational	29,900	-	9,200	20,700	-	-
resorts	167,900	-	23,000	46,000	-	98,900
summer homes	72,900	-	11,700	31,500	-	29,700

A-10. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050
Hydrographic Area No. 45 - Middle Fork Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total	399,800	248,900	40,600	97,600	9,600	3,100	13,600
developable area	11,830	560	1,420	6,830	2,400	620	80*
camp and picnic	2,090	560	210	1,020	240	60	-
organizational	1,170	-	160	750	260	-	-
resorts	1,590	-	270	960	170	190	80*
summer homes	6,980	-	780	4,100	1,730	370	-
No. of units (total)	22,870	2,800	2,710	12,540	3,670	1,150	200*
camp and picnic	10,450	2,800	1,050	5,100	1,200	300	-
organizational	1,460	-	200	940	320	-	-
resorts	3,980	-	680	2,400	420	480	200*
summer homes	6,960	-	780	4,100	1,730	370	-
Capacity people (total)	91,480	11,200	10,840	50,160	14,680	4,600	800*
camp and picnic	41,800						-
organizational	5,840						-
resorts	15,920						800*
summer homes	27,920						-
Capacity visitor days	10,584,200	1,288,000	1,246,600	5,768,400	1,686,200	429,000	64,000
camp and picnic	4,807,000						-
organizational	671,600						-
resorts	1,894,800						64,000
summer homes	3,210,800						-
Average annual visitor days - probable use							
total	6,683,000	952,000	798,200	3,599,200	960,220	341,400	32,000
camp and picnic	3,553,000	952,000	357,000	1,734,000	408,000	102,000	-
organizational	408,800	-	56,000	263,200	89,600	-	-
resorts	1,464,800	-	244,800	864,000	151,200	172,800	32,000
summer homes	1,256,400	-	140,400	738,000	311,400	66,600	-
Average annual visitor days - minimum use							
total	4,302,900	644,000	514,100	2,310,200	601,900	212,700	20,000
camp and picnic	2,403,500	644,000	241,500	1,173,000	276,000	69,000	-
organizational	335,800	-	46,000	216,200	73,600	-	-
resorts	935,400	-	156,400	552,000	96,600	110,400	20,000
summer homes	628,200	-	70,200	369,000	155,700	33,300	-

* Not included in total

A-11. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050
Hydrographic Area No. 46 - South Fork Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	100,900	11,900	20,000	64,600	1,600	2,800	3,500*
developable area	6,210	30	700	4,520	400	560	20*
camp and picnic	910	30	100	680	40	60	-
organizational	620	-	80	500	40	-	-
resorts	960	-	130	630	30	170	20*
summer homes	3,720	-	390	2,710	290	330	-
No. of units (total)	11,450	150	1,310	8,320	610	1,060	50*
camp and picnic	4,550	150	500	3,400	200	300	-
organizational	780	-	100	630	50	-	-
resorts	2,400	-	320	1,580	70	430	50*
summer homes	3,720	-	390	2,710	290	330	-
Capacity people (total)	45,800	600	5,240	33,280	2,440	4,240	200*
camp and picnic	18,200						
organizational	3,120						
resorts	9,600						
summer homes	14,880						
Capacity visitor days	5,283,000	69,000	602,600	3,827,200	280,600	487,600	16,000
camp and picnic	2,093,000						-
organizational	358,800						-
resorts	1,120,000						16,000
summer homes	1,711,200						-
Average annual visitor days - probable use							
total	3,307,000	51,000	383,400	2,389,000	159,400	316,200	8,000
camp and picnic	1,547,000	51,000	170,000	1,156,000	68,000	102,000	-
organizational	218,400	-	28,000	176,400	14,000	-	-
resorts	872,000	-	115,200	568,800	25,200	154,800	8,000
summer homes	669,600	-	70,200	487,800	52,200	59,400	-
Average annual visitor days - minimum use							
total	2,117,700	34,500	246,700	1,534,200	99,700	197,600	5,000
camp and picnic	1,046,500	34,500	115,000	782,00	46,000	69,000	-
organizational	179,400	-	23,000	144,900	11,500	-	-
resorts	557,000	-	73,600	363,400	16,100	98,900	5,000
summer homes	334,800	-	35,100	243,900	26,100	29,700	-

* Not included in total

A-12. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050
Hydrographic Areas No. 41-49 - UPPER FEATHER RIVER SERVICE AREA

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	2,138,000	1,111,100	334,900	575,400	80,300	36,300	36,000*
developable area	81,840	2,500	11,720	40,280	20,080	7,260	220*
camp and picnic	13,020	2,500	1,750	6,040	2,000	730	-
organizational	7,950	-	1,300	4,440	2,210	-	-
resorts	11,450	-	2,220	5,640	1,410	2,180	220*
summer homes	49,420	-	6,450	24,160	14,460	4,340	-
No. of units (total)	153,100	12,500	22,380	74,010	30,740	13,470	550*
camp and picnic	65,100	12,500	8,750	30,200	10,000	3,650	-
organizational	9,940	-	1,630	5,550	2,760	-	-
resorts	28,640	-	5,550	14,100	3,520	5,470	550*
summer homes	49,420	-	6,450	24,460	14,460	4,350	-
Capacity people	612,400	50,000	89,520	296,040	122,960	53,880	2,200*
camp and picnic	260,400						-
organizational	39,760						-
resorts	114,560						2,200*
summer homes	197,680						-
Capacity visitor days	70,602,000	5,750,000	10,294,800	34,044,600	14,140,400	6,196,200	176,000
camp and picnic	29,946,000						-
organizational	4,572,400						-
resorts	13,350,400						176,000
summer homes	22,733,200						-
Average annual visitor days - probable use							
total	44,211,200	4,250,000	6,590,400	21,246,800	8,042,800	3,993,200	88,000
camp and picnic	22,134,000	4,250,000	2,975,000	10,268,000	3,400,000	1,241,000	-
organizational	2,783,200	-	456,400	1,554,000	772,800	-	-
resorts	10,398,400	-	1,998,000	5,076,000	1,267,200	1,969,200	88,000
summer homes	8,895,600	-	1,161,000	4,348,800	2,602,800	783,000	-
Average annual visitor days - minimum use							
total	28,399,200	2,875,000	4,244,400	13,639,900	5,045,800	2,489,100	-
camp and picnic	14,973,000	2,875,000	2,012,500	6,946,000	2,300,000	839,500	-
organizational	2,286,200	-	374,900	1,276,500	634,800	-	-
resorts	6,642,200	-	1,276,500	3,243,000	809,600	1,258,100	-
summer homes	4,447,800	-	580,500	2,174,400	1,301,400	391,500	-

* Not included in total

A-13. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050
Hydrographic Areas Nos. 41, 48 and 49 - Foothill Area 1/

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban
Area in acres (total)	207,300	-	70,300	112,000	4,500	20,500
developable area	15,530	-	2,460	7,840	1,130	4,100
camp and picnic	2,070	-	370	1,180	110	410
organizational	1,350	-	270	860	120	-
resorts	2,880	-	470	1,100	80	1,230
summer homes	9,330	-	1,350	4,700	820	2,460
No. of units (total)	28,440	-	4,710	14,420	1,720	7,590
camp and picnic	10,350	-	1,850	5,900	550	2,050
organizational	1,560	-	340	1,070	150	-
resorts	7,200	-	1,170	2,750	200	3,080
summer homes	9,330	-	1,350	4,700	820	2,460
Capacity people (total)	113,760	-	18,840	57,680	6,880	30,360
camp and picnic	41,400					
organizational	6,240					
resorts	28,800					
summer homes	37,320					
Capacity visitor days	13,082,400	-	2,166,600	6,633,200	791,200	3,491,400
camp and picnic	4,761,000					
organizational	717,600					
resorts	3,312,000					
summer homes	4,291,800					
Average annual visitor days - probable use						
total	8,227,220	-	1,388,400	4,141,600	448,600	2,248,600
camp and picnic	3,519,000	-	629,000	2,006,000	187,000	697,000
organizational	436,800	-	95,200	299,600	42,000	-
resorts	2,592,000	-	421,200	990,000	72,000	1,108,800
summer homes	1,679,400	-	243,000	846,000	147,600	442,800
Average annual visitor days - minimum use						
total	5,235,000	-	894,300	2,658,600	280,800	1,401,300
camp and picnic	2,380,500	-	425,500	1,357,000	126,500	471,500
organizational	358,800	-	78,200	246,100	34,500	-
resorts	1,656,000	-	269,100	632,500	46,000	708,400
summer homes	839,700	-	121,500	423,000	73,800	221,400

1. Paradise, Challenge and Wyandotte, respectively

A-14. ULTIMATE POTENTIAL RECREATION USE WITHOUT ADDITIONAL WATER DEVELOPMENT - 2050
Hydrographic Areas No. 42-46 - UPPER FEATHER RIVER BASIN

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	1,934,600	1,111,100	264,600	463,400	75,800	15,800	36,000*
developable area	66,310	2,500	9,260	32,440	18,950	3,160	220*
camp and picnic	10,950	2,500	1,380	4,860	1,890	320	-
organizational	6,700	-	1,030	3,580	2,090	-	-
resorts	8,570	-	1,750	4,540	1,330	950	220*
summer homes	40,090	-	5,100	19,460	13,640	1,890	-
No. of units (total)	124,660	12,500	17,670	59,590	29,020	5,880	550*
camp and picnic	54,750	12,500	6,900	24,300	9,450	1,600	-
organizational	8,380	-	1,290	4,480	2,610	-	-
resorts	21,440	-	4,380	11,350	3,320	2,390	-
summer homes	40,090	-	5,100	19,460	13,640	1,890	-
Capacity people (total)	498,640	50,000	70,680	238,360	116,080	23,520	2,200*
camp and picnic	219,000						-
organizational	33,520						-
resorts	85,760						2,200*
summer homes	160,360						-
Capacity visitor days	57,519,600	5,750,000	8,128,200	27,411,400	13,349,200	2,704,800	176,000
camp and picnic	25,185,000						-
organizational	3,854,800						-
resorts	10,038,400						176,000
summer homes	18,441,400						-
Average annual visitor days - probable use							
total	35,984,000	4,250,000	5,202,000	17,105,200	7,594,200	1,744,600	88,000
camp and picnic	18,615,000	4,250,000	2,346,000	8,262,000	3,213,000	544,000	-
organizational	2,346,400	-	361,200	1,254,400	730,800	-	-
resorts	7,806,400	-	1,576,800	4,086,000	1,195,200	860,400	88,000
summer homes	7,216,200	-	918,000	3,502,800	2,455,200	340,200	-
Average annual visitor days - minimum use							
total	23,114,200	2,875,000	3,350,100	10,981,300	4,765,000	1,087,800	55,000
camp and picnic	12,592,500	2,875,000	1,587,000	5,589,000	2,173,500	368,000	-
organizational	1,927,400	-	296,700	1,030,400	600,300	-	-
resorts	4,986,200	-	1,007,400	2,610,500	763,600	549,700	55,000
summer homes	3,608,100	-	459,000	1,751,400	1,227,600	170,100	-

* Not included in total

A-15. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050
Hydrographic Area No. 42 - North Fork Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total	635,600	125,200	209,000	183,800	112,400	5,200	7,500*
developable area	49,600	280	7,310	12,870	28,100	1,040	50*
camp and picnic	6,220	280	1,100	1,930	2,810	100	-
organizational	5,310	-	800	1,420	3,090	-	-
resorts	5,480	-	1,390	1,800	1,970	320	50*
summer homes	32,590	-	4,020	7,720	20,230	620	-
No. of units (total)	84,030	1,400	13,990	23,650	43,070	1,920	130*
camp and picnic	31,100	1,400	5,500	9,650	14,050	500	-
organizational	6,640	-	1,000	1,780	3,800	-	-
resorts	13,700	-	3,470	4,500	4,930	800	130*
summer homes	32,590	-	4,020	7,720	20,230	620	-
Capacity people (total)	336,120	5,600	55,960	94,600	172,280	7,680	520*
camp and picnic	124,400						-
organizational	26,560						-
resorts	54,800						520*
summer homes	130,360						-
Capacity visitor days	38,713,600	644,000	6,435,400	10,879,000	19,812,200	883,200	59,800
camp and picnic	14,306,000						
organizational	3,054,400						
resorts	6,361,800						59,800
summer homes	14,991,400						
Average annual visitor days - probable use							
total	23,252,200	476,000	4,122,800	6,789,000	11,273,800	569,600	20,800
camp and picnic	10,574,000	476,000	1,870,000	3,281,000	4,777,000	170,000	-
organizational	1,859,200	-	280,000	498,400	1,080,800	-	-
resorts	4,952,800	-	1,249,200	1,620,000	1,774,800	288,000	20,800
summer homes	5,866,200	-	723,600	1,389,600	3,641,200	111,600	-
Average annual visitor days - minimum use							
total	14,777,300	322,000	2,654,900	4,358,700	7,073,900	354,800	13,000
camp and picnic	7,153,000	322,000	1,265,000	2,219,500	3,231,500	115,000	-
organizational	1,527,200	-	230,000	409,400	887,800	-	-
resorts	3,164,000	-	798,100	1,035,000	1,133,900	184,000	13,000
summer homes	2,933,100	-	361,800	694,800	1,820,700	55,800	-

*Not included in total

A-16. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050
Hydrographic Area No. 43 - East Branch Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Genesee Park	Winter Sports
Area in acres (total)	589,300	379,100	45,200	103,400	55,000	4,400	11,200	11,400*
developable areas	27,740	830	1,560	7,240	13,750	880	460	70*
camp and picnic	3,950	830	240	1,090	1,380	90	320	-
organizational	2,480	-	170	800	1,510	-	-	-
resorts	2,670	-	300	1,010	960	260	140	70*
summer homes	15,640	-	870	4,340	9,900	530	-	-
No. of units (total)	46,370	4,150	3,030	13,320	21,090	1,630	3,150	170*
camp and picnic	20,950	4,150	1,200	5,450	6,900	450	2,800	-
organizational	3,100	-	210	1,000	1,890	-	-	-
resorts	6,680	-	750	2,530	2,400	650	350	180*
summer homes	15,640	-	870	4,340	9,900	530	-	-
Capacity people (total)	185,480	16,600	12,120	53,280	84,360	6,520	12,600	720*
camp and picnic	83,800							
organizational	12,400							
resorts	26,720							720*
summer homes	62,560							
Capacity visitor days	21,387,800	1,909,000	1,393,800	6,127,200	9,701,400	749,800	1,449,000	57,600
camp and picnic	9,426,000							
organizational	1,426,000							
resorts	3,130,400							57,600
summer homes	7,194,400							
Average annual visitor days - probable use								
total	13,239,800	1,411,000	893,400	3,825,000	5,521,200	482,400	1,078,000	28,800
camp and picnic	7,123,000	1,411,000	408,000	1,853,000	2,346,000	153,000	952,000	-
organizational	868,000	-	58,800	280,000	529,200	-	-	-
resorts	2,433,600	-	270,000	910,800	864,000	234,000	126,000	28,800
summer homes	2,815,200	-	156,600	781,200	1,782,000	95,400	-	-
Average annual visitor days - minimum use								
total	8,493,500	954,500	575,100	2,456,000	3,464,700	300,700	724,500	18,000
camp and picnic	4,818,500	954,500	276,000	1,253,500	1,587,000	103,500	644,000	-
organizational	713,000	-	48,300	230,000	434,700	-	-	-
resorts	1,554,400	-	172,500	581,900	552,000	149,500	80,500	18,000
summer homes	1,407,600	-	78,300	390,600	891,000	47,700	-	-

* Not included in total

A-17. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT – [illegible]
Hydrographic Area No. 44 – Sierra Valley

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban
Area in acres (total)	207,600	167,400	13,700	8,400	13,300	4,800
developable areas	5,720	380	480	590	3,310	960
camp and picnic	970	380	70	90	330	100
organizational	470	-	50	60	360	-
resorts	690	-	90	80	230	290
summer homes	3,590	-	270	360	2,390	570
No. of units (total)	10,760	1,900	900	1,090	5,070	1,800
camp and picnic	4,850	1,900	350	450	1,650	500
organizational	590	-	60	80	450	-
resorts	1,730	-	220	200	580	730
summer homes	3,590	-	270	360	2,390	570
Capacity people (total)	43,040	7,600	3,600	4,360	20,280	7,200
camp and picnic	19,400					
organizational	2,360					
resorts	6,920					
summer homes	14,360					
Capacity visitor days	4,949,600	874,000	414,000	501,400	2,332,200	828,000
camp and picnic	2,231,000					
organizational	271,400					
resorts	795,800					
summer homes	1,651,400					
Average annual visitor days – probable use						
total	3,083,200	646,000	243,600	312,200	1,326,000	535,400
camp and picnic	1,649,000	646,000	119,000	153,000	561,000	170,000
organizational	165,200	-	16,800	22,400	126,000	-
resorts	622,800	-	79,200	72,000	208,800	262,800
summer homes	646,200	-	48,600	64,800	430,200	102,600
Average annual visitor days – minimum use						
total	1,972,200	437,000	169,200	200,300	831,500	334,200
camp and picnic	1,115,500	437,000	80,500	103,500	379,500	115,000
organizational	135,700	-	13,800	18,400	103,500	-
resorts	397,900	-	50,600	46,000	133,400	167,900
summer homes	323,100	-	24,300	32,400	215,100	51,300

A-18. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050

Hydrographic Area No. 45 - Middle Fork Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	403,400	190,100	73,900	84,000	51,000	4,400	12,600*
developable areas	22,530	430	2,590	5,880	12,750	880	80*
camp and picnic	3,070	430	390	880	1,280	90	-
organizational	2,330	-	280	650	1,400	-	-
resorts	2,460	-	490	820	890	260	80*
summer homes	14,670	-	1,430	3,530	9,180	530	-
No. of units (total)	39,080	2,150	4,950	10,790	19,560	1,630	200*
camp and picnic	15,350	2,150	1,950	4,400	6,400	450	-
organizational	2,910	-	350	810	1,750	-	-
resorts	6,150	-	1,220	2,050	2,230	650	200*
summer homes	14,670	-	1,430	3,530	9,180	530	-
Capacity people (total)	156,320	8,600	19,800	43,160	78,240	6,520	800*
camp and picnic	61,400						
organizational	11,640						
resorts	24,600						800*
summer homes	58,680						
Capacity visitor days	18,040,800	989,000	2,277,000	4,963,400	8,997,600	749,800	64,000
camp and picnic	7,061,000						
organizational	1,338,600						
resorts	2,893,000						
summer homes	6,748,200						
Average annual visitor days - probable use							
total	10,920,400	731,000	1,457,600	3,096,200	5,121,200	482,400	32,000
camp and picnic	5,219,000	731,000	663,000	1,496,000	2,176,000	153,000	-
organizational	814,800	-	98,000	226,800	490,000	-	-
resorts	2,246,000	-	439,200	738,000	802,800	234,000	32,000
summer homes	2,640,600	-	257,400	635,400	1,652,400	95,400	-
Average annual visitor days - minimum use							
total	6,954,600	494,500	938,300	1,987,500	3,213,600	300,700	20,000
camp and picnic	3,530,500	494,500	448,500	1,012,000	1,472,000	103,500	-
organizational	669,300	-	80,500	186,300	402,500	-	-
resorts	1,434,500	-	280,600	471,500	512,900	149,500	20,000
summer homes	1,320,300	-	128,700	317,700	826,200	47,700	-

* Not included in total

A-19. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050
Hydrographic Area No. 46 - South Fork Feather River

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	98,700	10,800	8,000	57,600	18,400	3,900	3,500*
developable areas	9,710	20	280	4,030	4,600	780	20*
camp and picnic	1,200	20	40	600	460	80	-
organizational	980	-	30	440	510	-	-
resorts	1,160	-	50	560	320	230	20*
summer homes	6,370	-	160	2,430	3,310	470	-
No. of units (total)	16,500	100	520	7,380	7,050	1,450	50*
camp and picnic	6,000	100	200	3,000	2,300	400	-
organizational	1,230	-	40	550	640	-	-
resorts	2,900	-	120	1,400	800	580	50*
summer homes	6,370	-	160	2,430	3,310	470	-
Capacity people (total)	66,000	400	2,080	29,520	28,200	5,800	200*
camp and picnic	24,000						
organizational	4,920						
resorts	11,600						200*
summer homes	25,480						
Capacity visitor days	7,606,000	46,000	239,200	3,394,800	3,243,000	667,000	16,000
camp and picnic	2,760,000						
organizational	565,800						
resorts	1,350,000						
summer homes	2,930,200						
Average annual visitor days - probable use							
total	4,583,000	34,000	151,200	2,115,400	1,845,000	429,400	8,000
camp and picnic	2,040,000	34,000	68,000	1,020,000	782,000	136,000	-
organizational	344,400	-	11,200	154,000	179,200	-	-
resorts	1,052,000	-	43,200	504,000	288,000	208,800	8,000
summer homes	1,146,600	-	28,800	437,400	595,800	84,600	-
Average annual visitor days - minimum use							
total	2,908,200	23,000	97,200	1,357,200	1,158,100	267,700	5,000
camp and picnic	1,380,000	23,000	46,000	690,000	529,000	92,000	-
organizational	282,900	-	9,200	126,500	147,200	-	-
resorts	672,000	-	27,600	322,000	184,000	133,400	5,000
summer homes	573,300	-	14,400	218,700	297,900	42,300	-

*Not included in total

A-20. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050
UPPER FEATHER RIVER BASIN (Areas No. 42 - 46)

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Genesee Park	Winter Sports
Area in acres (total)	1,934,600	863,600	349,800	437,200	250,100	22,700	11,200	36,000*
developable areas	112,300	1,940	12,240	30,610	62,510	4,540	460	220*
camp and picnic	15,410	1,940	1,840	4,590	6,260	460	320	-
organizational	11,570	-	1,330	3,370	6,870	-	-	-
resorts	12,460	-	2,320	4,270	4,370	1,360	140	220*
summer homes	72,860	-	6,750	18,380	45,010	2,720	-	-
No. of units (total)	196,740	9,700	33,390	56,230	95,840	8,430	3,150	550*
camp and picnic	78,250	9,700	9,200	22,950	31,300	2,300	2,800	-
organizational	14,470	-	1,660	4,220	8,590	-	-	-
resorts	31,160	-	5,780	10,680	10,940	3,410	350	550*
summer homes	72,860	-	6,750	18,380	45,010	2,720	-	-
Capacity people (total)	786,960	38,800	93,560	224,920	383,360	33,720	12,600	2,200
camp and picnic	313,000							
organizational	57,880							
resorts	124,640							
summer homes	291,440							
Capacity visitor days	90,676,400	4,462,000	10,759,400	25,865,800	44,086,400	3,877,800	1,449,000	176,000
camp and picnic	35,995,000							
organizational	6,656,200							
resorts	14,509,600							176,000
summer homes	33,515,600							
Average annual visitor days - probable use								
total	55,077,000	3,298,000	6,888,600	16,137,800	25,087,400	2,499,200	1,078,000	88,000
camp and picnic	26,605,000	3,298,000	3,128,000	7,803,000	10,642,000	782,000	952,000	-
organizational	4,051,600	-	464,800	1,181,600	2,405,200	-	-	-
resorts	11,305,600	-	2,080,800	3,844,800	3,938,400	1,227,600	126,000	88,000
summer homes	13,114,800	-	1,215,000	3,308,400	8,101,800	489,600	-	-
Average annual visitor days - minimum use								
total	35,104,800	2,231,000	4,434,700	10,359,700	15,741,800	1,558,100	724,500	55,000
camp and picnic	17,997,500	2,231,000	2,116,000	5,278,500	7,199,000	529,000	644,000	-
organizational	3,328,100	-	381,800	970,600	1,975,700	-	-	-
resorts	7,221,800	-	1,329,400	2,456,400	2,516,200	784,300	80,500	55,000
summer homes	6,557,400	-	607,500	1,654,200	4,050,900	244,800	-	-

* Not included in total

A-21. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050
Hydrographic Areas No. 41, 48 and 49 - Foothill Areas 1/

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Winter Sports
Area in acres (total)	217,100	-	69,800	100,600	19,600	27,100	-
developable areas	19,820	-	2,440	7,040	4,920	5,420	-
camp and picnic	2,460	-	370	1,060	490	540	-
organizational	1,580	-	270	770	540	-	-
resorts	3,420	-	460	990	340	1,630	-
summer homes	12,360	-	1,340	4,200	3,550	3,250	-
No. of units (total)	35,190	-	4,680	12,950	7,530	10,030	-
camp and picnic	12,300	-	1,850	5,300	2,450	2,700	-
organizational	1,980	-	340	960	680	-	-
resorts	8,550	-	1,150	2,470	850	4,080	-
summer homes	12,360	-	1,340	4,220	3,550	3,250	-
Capacity people (total)	140,760	-	18,720	51,800	30,120	40,120	-
camp and picnic	49,200						
organizational	7,920						
resorts	34,200						
summer homes	49,440						
Capacity visitor days	16,187,400	-	2,152,800	5,957,000	3,463,800	4,613,800	-
camp and picnic	5,658,000						
organizational	910,800						
resorts	3,933,000						
summer homes	5,685,600						
Average annual visitor days - probable use							
total	10,039,220	-	1,379,400	3,719,600	1,968,400	2,971,800	-
camp and picnic	4,182,000	-	629,000	1,802,000	833,000	918,000	-
organizational	554,400	-	95,200	268,800	190,400	-	-
resorts	3,078,000	-	414,000	889,200	306,000	1,468,800	-
summer homes	2,224,800	-	241,200	759,600	639,000	585,000	-
Average annual visitor days - minimum use							
total	6,363,300	-	888,800	2,387,700	1,234,900	1,851,900	-
camp and picnic	2,829,000	-	425,500	1,219,000	563,500	621,000	-
organizational	455,400	-	78,200	220,800	156,400	-	-
resorts	1,966,500	-	264,500	568,100	195,500	938,400	-
summer homes	1,112,400	-	120,600	379,800	319,500	292,500	-

1/ Paradise, Challenge and Wyandotte respectively.

A-22. POTENTIAL RECREATION USE WITH ULTIMATE STATE WATER DEVELOPMENT - 2050
Hydrographic Areas 41 - 49 - UPPER FEATHER RIVER SERVICE AREA

	Total	Nature Reserves	Natural Areas	River and Stream	Reservoir Recreation	Urban and Suburban	Genesee Park	Winter Sports
Area in acres (total)	2,151,700	863,600	419,600	537,800	269,700	49,800	11,200	36,000*
developable areas	132,120	1,940	14,680	37,650	67,430	9,960	460	220*
camp and picnic	17,870	1,940	2,210	5,650	6,750	1,000	320	-
organizational	13,150	-	1,600	4,140	7,410	-	-	-
resorts	15,880	-	2,780	5,260	4,710	2,990	140	220*
summer homes	85,220	-	8,090	22,600	48,560	5,970	-	-
No. of units (total)	231,930	9,700	28,070	69,180	103,370	18,460	3,150	550*
camp and picnic	90,550	9,700	11,050	28,250	33,750	5,000	2,800	-
organizational	16,450	-	2,000	5,180	9,270	-	-	-
resorts	39,710	-	6,930	13,150	11,790	7,490	350	550*
summer homes	85,220	-	8,090	22,600	48,560	5,970	-	-
Capacity people (total)	927,720	38,300	112,280	276,720	413,480	73,840	12,600	2,200*
camp and picnic	362,200							
organizational	65,800							
resorts	158,840							2,200*
summer homes	340,880							
Capacity visitor days	106,863,800	4,462,000	12,912,200	31,822,800	47,550,200	8,491,600	1,449,000	176,000
camp and picnic	41,653,000							
organizational	7,567,000							
resorts	18,442,600							
summer homes	39,201,200							
Average annual visitor days - probable use								
total	65,116,200	3,298,000	8,268,000	19,857,400	27,055,800	5,471,000	1,078,000	88,000
camp and picnic	30,787,000	3,298,000	3,757,000	9,605,000	11,475,000	1,700,000	952,000	-
organizational	4,606,000	-	560,000	1,450,400	2,595,600	-	-	-
resorts	14,383,600	-	2,494,800	4,734,000	4,244,400	2,696,400	126,000	88,000
summer homes	15,339,600	-	1,456,200	4,068,000	8,740,800	1,074,600	-	-
Average annual visitor days - minimum use								
total	41,468,100	2,231,000	5,323,500	12,747,400	16,976,700	3,410,000	724,500	55,000
camp and picnic	20,826,500	2,231,000	2,541,500	6,497,500	7,762,500	1,150,000	644,000	-
organizational	3,783,500	-	460,000	1,191,400	2,132,100	-	-	-
resorts	9,188,300	-	1,593,900	3,024,500	2,711,700	1,722,700	80,500	55,000
summer homes	7,669,800	-	728,100	2,034,000	4,370,400	537,300	-	-

* Not included in total

A-23. PERCENTAGES OF GENERAL LAND USES IN THE UPPER FEATHER RIVER BASIN, UPPER FEATHER RIVER SERVICE AREA WITH AND WITHOUT ADDITIONAL WATER DEVELOPMENT, 1956 AND ULTIMATELY, YEAR 2050.

		Basin Ultimate 2050		Service Area Ultimate 2050	
	Existing	Water Development			
General Land Use	1956	Without	With	Without	With
Agricultural	-	14.2	12.1	16.7	14.5
Water	1.8	1.8	3.5	1.5	3.1
General recreation areas	-	84.0	84.4	81.8	82.4
Total	-	100.0	100.0	100.0	100.0
General Recreation Areas					
nature reserves	-	48.4	37.7	42.5	33.1
natural areas	-	11.4	15.2	12.8	16.1
river and stream	-	20.2	19.1	22.0	20.6
reservoirs and lakes	-	3.3	10.9	3.1	10.3
urban and suburban	-	0.7	1.0	1.4	1.9
winter sports	-	1.6*	1.6*	1.4*	1.4*
Genesee Park area	-	-	0.5	-	0.4
	-				
Total	-	84.0	84.4	81.8	82.4
undevelopable areas	-	81.1	79.5	78.7	77.3
developable areas	0.11	2.9	4.9	3.1	5.1
percent of developable areas (developable area equals 100%)					
camp and picnic	21.5	16.5	13.7	15.9	13.5
organization camps	7.1	10.1	10.3	9.7	10.0
resorts, hotels, motels	31.5	12.9	11.1	14.0	12.0
summer homes	40.0	60.5	64.9	60.4	64.5

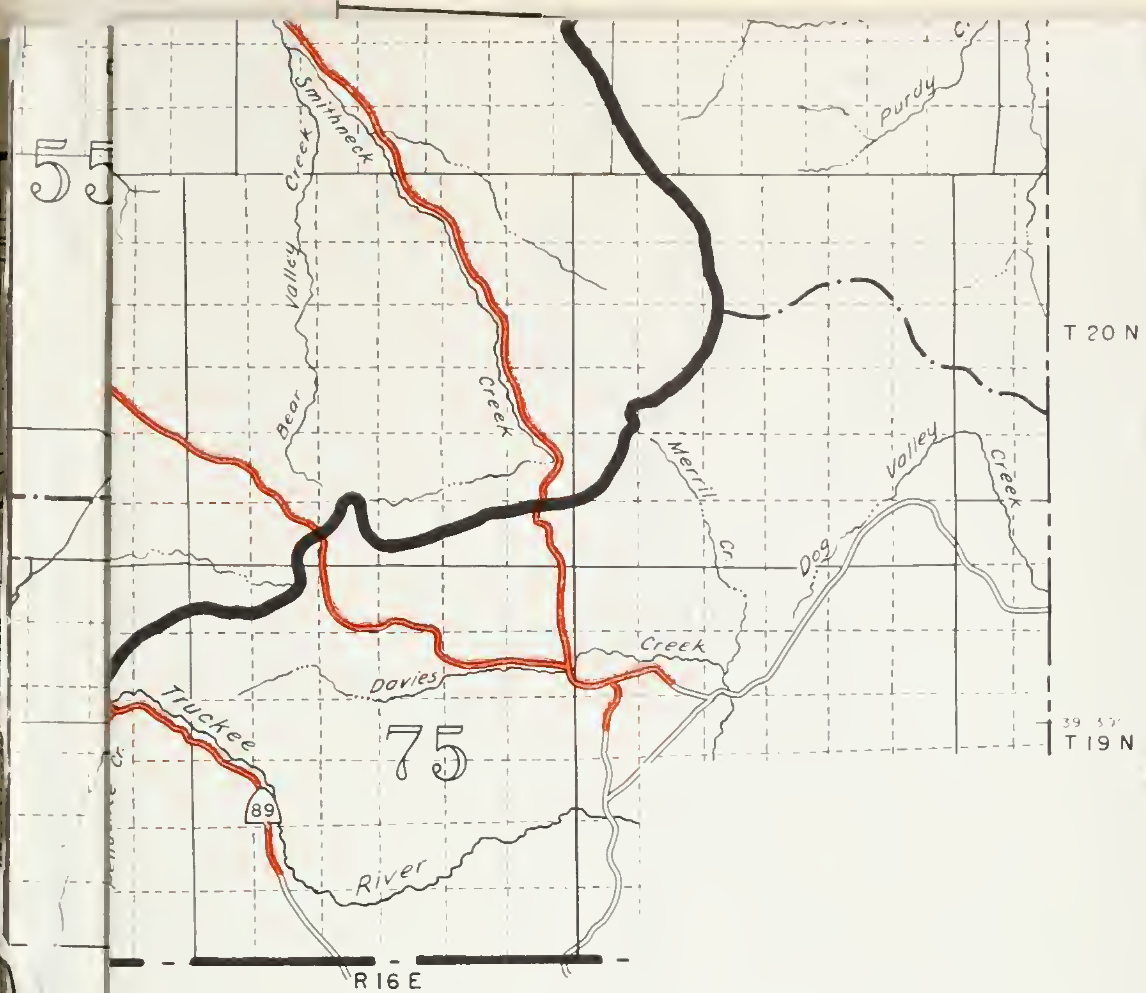
* Winter sports areas overlap general recreation areas and are not included in the total.

A-24. GROSS AND NET RECREATION USE DENSITIES ON THE UPPER FEATHER RIVER SERVICE AREA BY HYDROGRAPHIC AREAS, WITH AND WITHOUT ADDITIONAL WATER DEVELOPMENT - 1956 AND ULTIMATE 2050.

	Average Recreation Units per acre			Average Capacity People per acre		
		Ultimate 2050 Water Development			Ultimate 2050 Water Development	
Hydrographic Area	Existing 1956	Without	With	Existing 1956	Without	With
Gross densities (total area of hydrographic area)						
42. North Fork	0.003	0.09	0.14	0.013	0.34	1.69
43. East Branch	0.001	0.03	0.07	0.005	0.12	1.87
44. Sierra Valley	0.0004	0.01	0.05	0.001	0.05	1.88
45. Middle Fork	0.002	0.05	0.09	0.007	0.21	1.73
46. South Fork	0.001	0.11	0.16	0.006	0.45	1.70
Average for Upper Basin	0.002	0.05	0.09	0.007	0.20	1.75
Foothill areas	-	0.09	0.11	-	0.36	1.78
Average for Service Area	-	0.06	0.09	-	0.23	1.76
Net densities of developable areas						
42. North Fork	1.7	1.77	1.69	8.2	7.07	6.78
43. East Branch	1.7	2.17	1.87	6.5	8.74	7.50
44. Sierra Valley	1.4	2.58	1.88	5.8	10.32	7.52
45. Middle Fork	0.9	1.93	1.73	3.9	7.73	6.94
46. South Fork	1.8	1.84	1.70	8.7	7.38	6.80
Average for Upper Basin	1.5	1.88	1.75	6.5	7.07	7.01
Foothill Areas	-	1.83	1.78	-	7.33	7.10
Average for Service Area	-	1.87	1.76	-	7.48	7.02

A-25. EXISTING AND PROBABLE PERCENTAGES OF ANNUAL VISITOR-DAYS USE BY HYDROGRAPHIC AREAS IN THE UPPER FEATHER RIVER SERVICE AREA, 1956 AND ULTIMATELY, 2050

Recreation Areas	Upper Basin Existing 1956	Upper Basin Ultimate 2050 Water Development Without	Upper Basin Ultimate 2050 Water Development With	Service Area Ultimate 2050 Water Development Without	Service Area Ultimate 2050 Water Development With
Total Probable Annual Visitor-days for developed areas equals 100%					
Hydrographic Areas:					
42. North Fork	55.9	51.6	42.3	42.0	35.8
43. East Branch	22.0	16.6	24.0	13.6	20.4
44. Sierra Valley	2.5	4.0	5.6	3.3	4.7
45. Middle Fork	17.2	18.6	19.8	15.0	16.8
46. South Fork	2.4	9.2	8.3	7.5	7.0
41, 48, 49 Foothill Areas	-	-	-	18.6	15.3
Recreation Facilities:					
camp and picnic	47.6	51.6	50.0	48.3	47.2
organization camps	6.1	6.5	6.3	7.4	7.1
resorts, hotels and motels	31.2	21.8	23.5	20.5	22.1
summer homes	15.1	20.1	20.2	23.8	23.6
General Recreation Areas:					
nature reserves		11.8	6.0	9.6	5.1
natural areas		14.5	12.3	14.9	12.7
river and stream		47.6	29.3	48.1	30.6
reservoir and lakes		21.0	45.6	18.2	41.6
urban		4.9	4.5	9.0	8.4
winter sports		0.2	0.2	0.2	0.1
Genesee Park		-	2.0	-	1.7



ACILITIES
ASIN: 1956

SEARCH

N

CAMPS

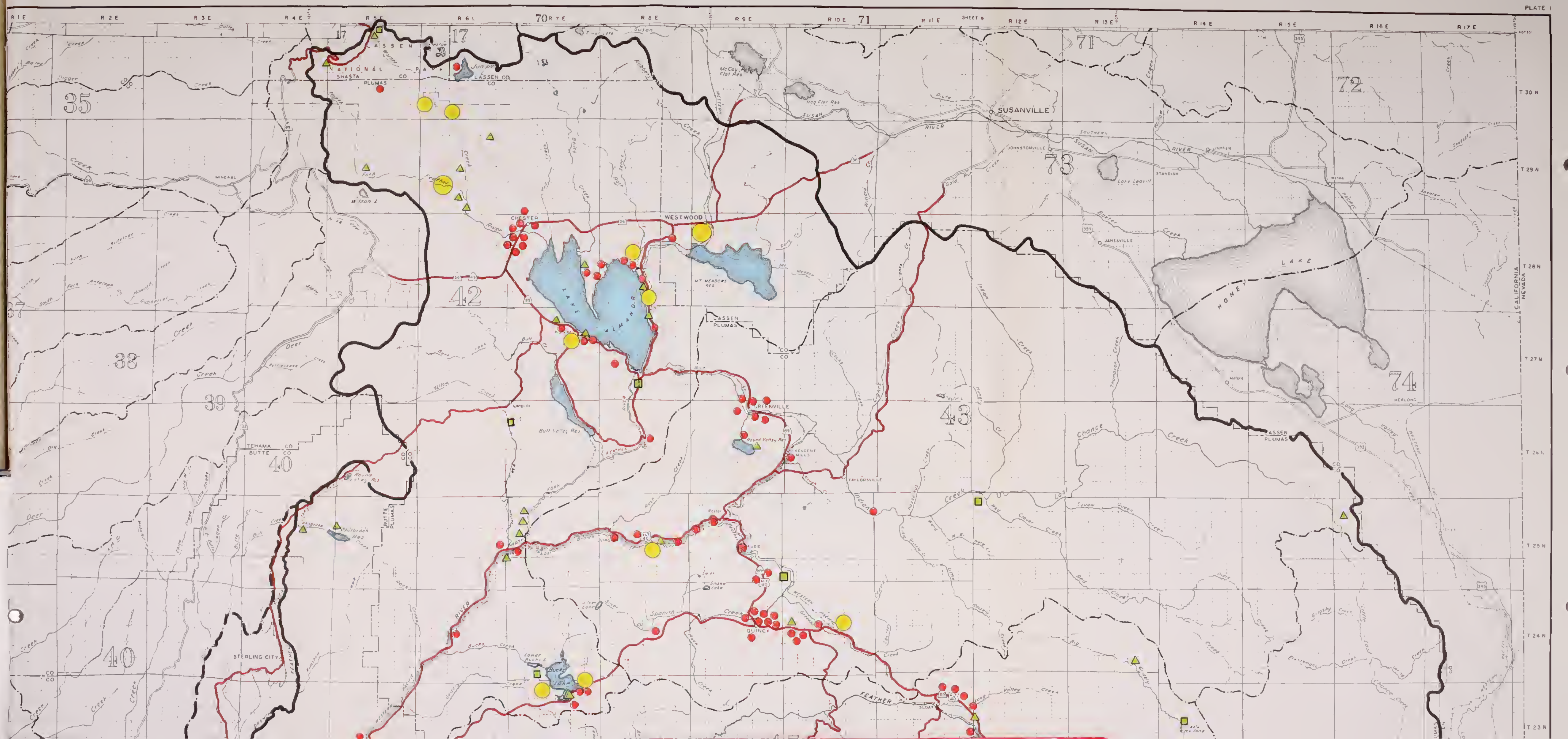


PLATE I
R 1 E
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
R 13 E
R 14 E
R 15 E
R 16 E
R 17 E
T 30 N
T 29 N
T 28 N
T 27 N
T 25 N
T 24 N
T 23 N
70
71
72
73
74
17
35
38
39
40
42
43
LASSEN NATIONAL PARK
SHASTA CO
PLUMAS
LASSEN CO
SUSANVILLE
JOHNSTONVILLE
STANDISH
JANESVILLE
WESTWOOD
CHESTER
LAKE ALMANOR
GREENVILLE
CRESCENT MILLS
TAYLORSVILLE
QUINCY
STERLING CITY
TEHAMA CO
BUTTE CO
LASSEN
PLUMAS
HONEY LAKE
MILFORD
HERLONG
CALIFORNIA
NEVADA

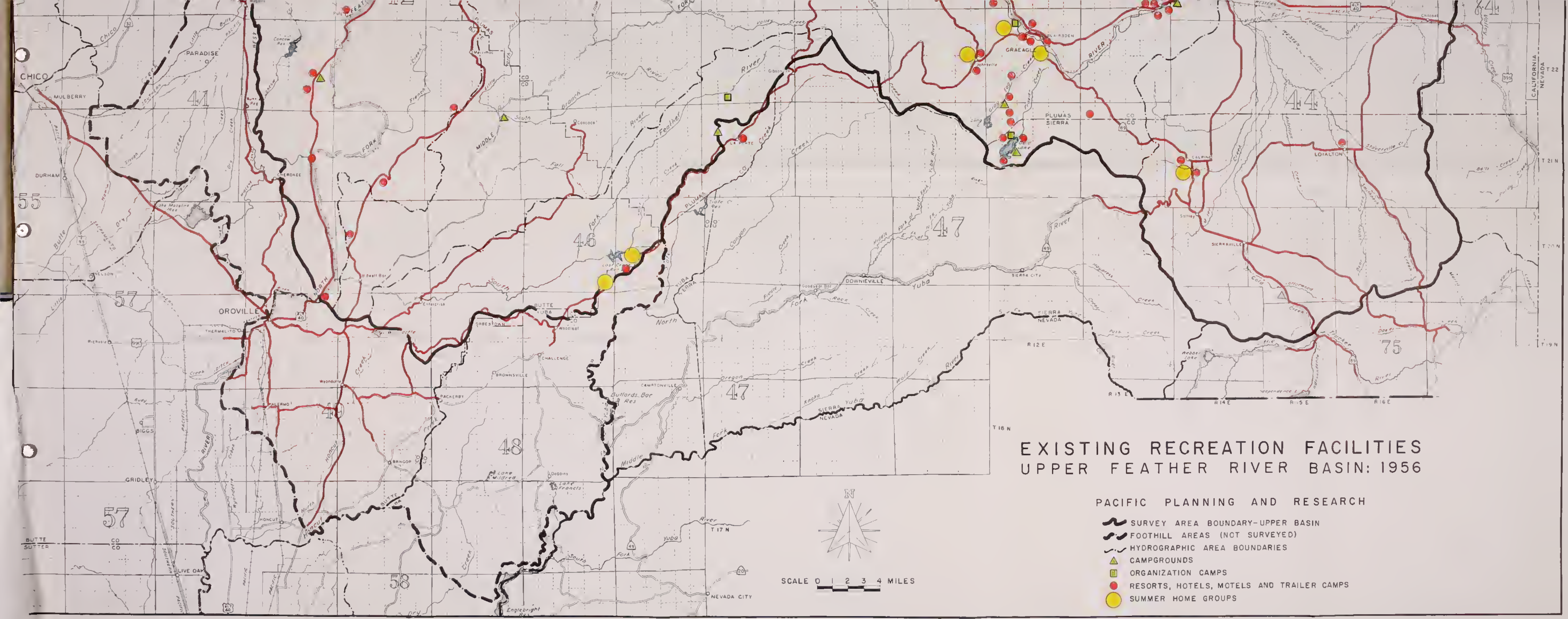
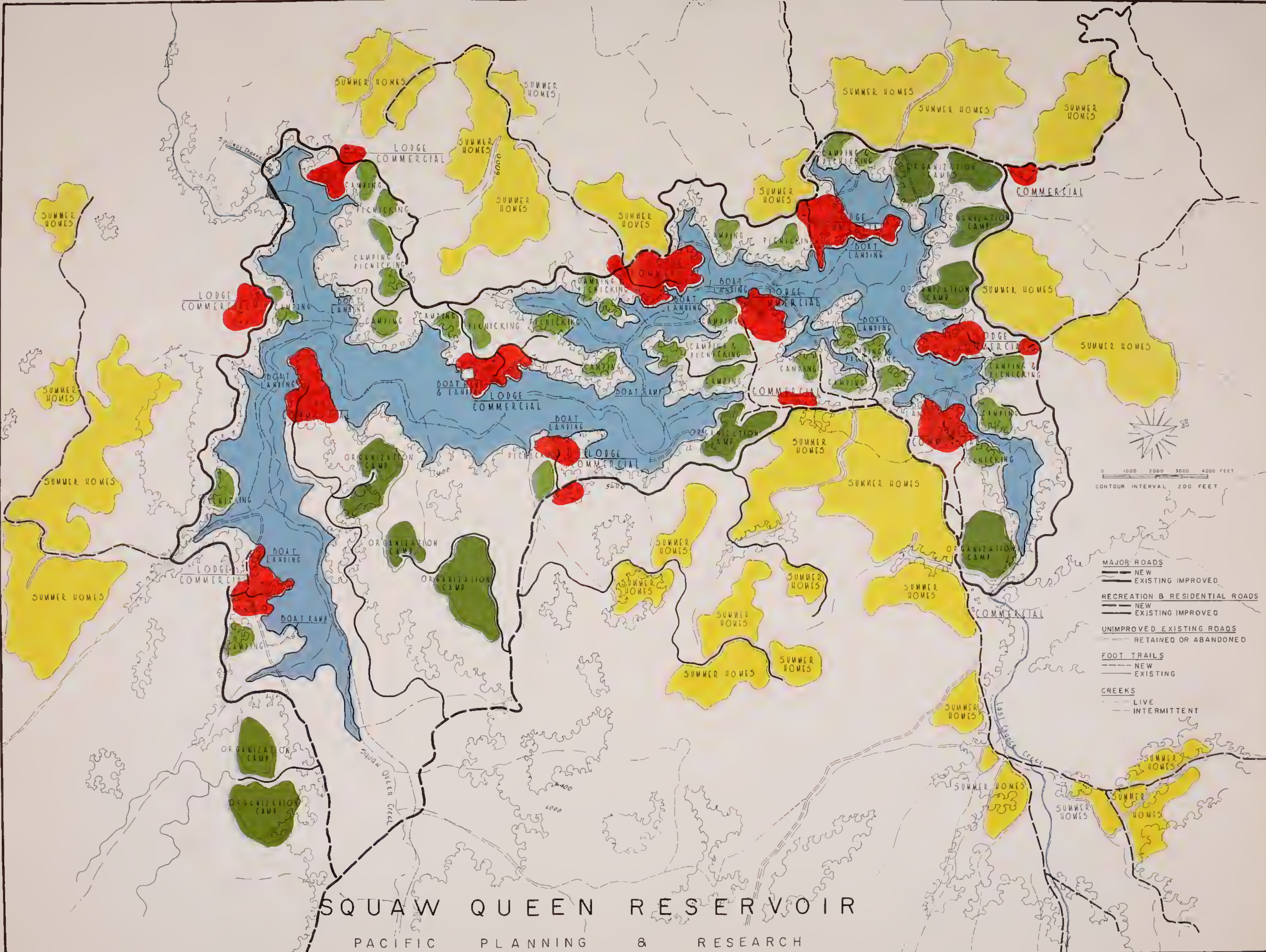
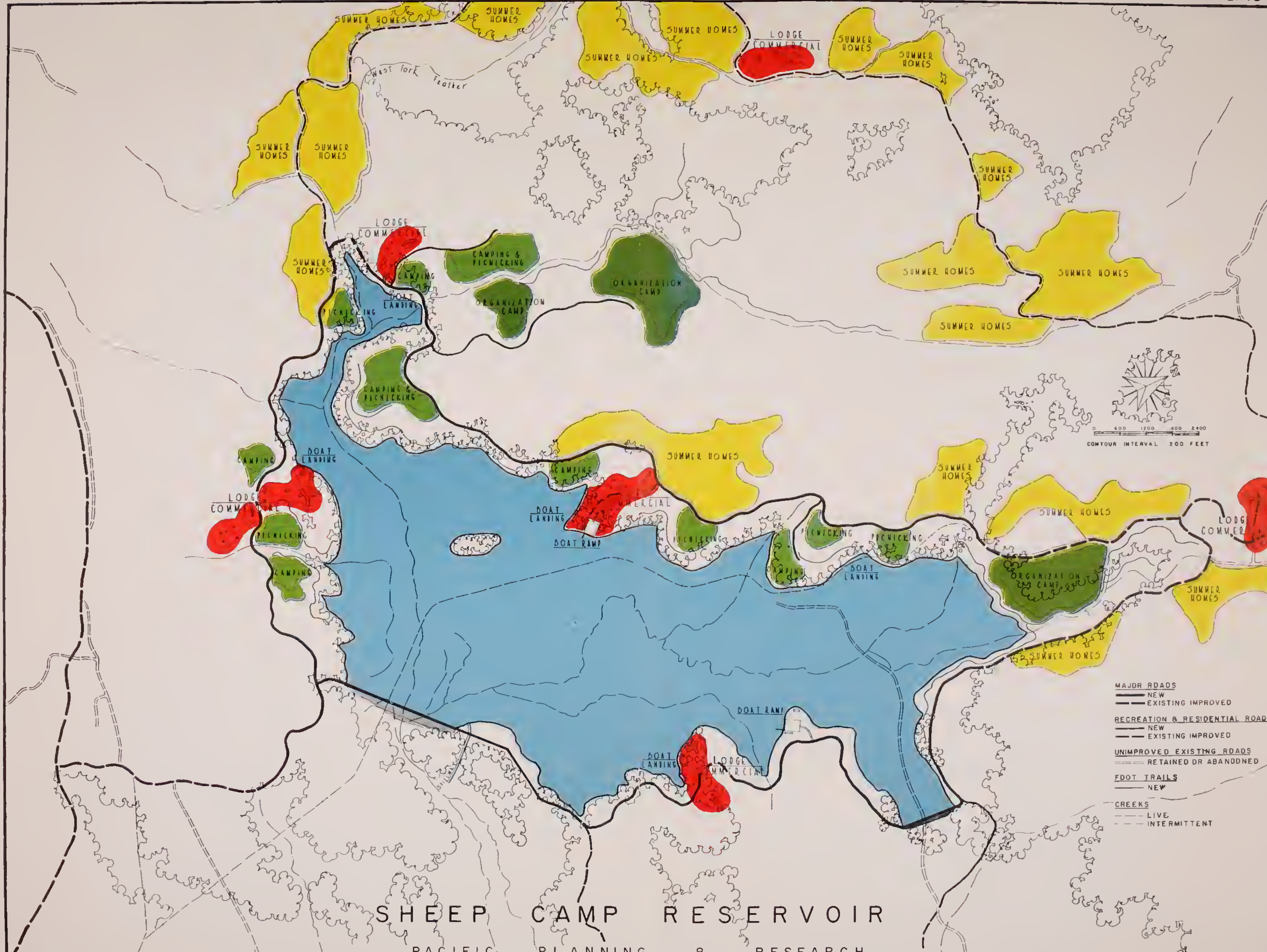

EXISTING RECREATION FACILITIES
UPPER FEATHER RIVER BASIN: 1956
PACIFIC PLANNING AND RESEARCH
SURVEY AREA BOUNDARY-UPPER BASIN
FOOTHILL AREAS (NOT SURVEYED)
HYDROGRAPHIC AREA BOUNDARIES
CAMPGROUNDS
ORGANIZATION CAMPS
RESORTS, HOTELS, MOTELS AND TRAILER CAMPS
SUMMER HOME GROUPS
SCALE 0 1 2 3 4 MILES
N
CHICO
PARADISE
MULBERRY
DURHAM
OROVILLE
THERMALITO
BIGGS
GRIDLEY
LIVE OAK
BUTTE
SUTTER
PLUMAS
SIERRA
GRAEAGLE
LOYALTON
SIERRAVILLE
SIERRA CITY
DOWNIEVILLE
CAMPTONVILLE
BROWNSVILLE
CHALLENGE
BANGOR
NEVADA CITY
CALIFORNIA
NEVADA
41
44
46
47
48
55
57
58
75

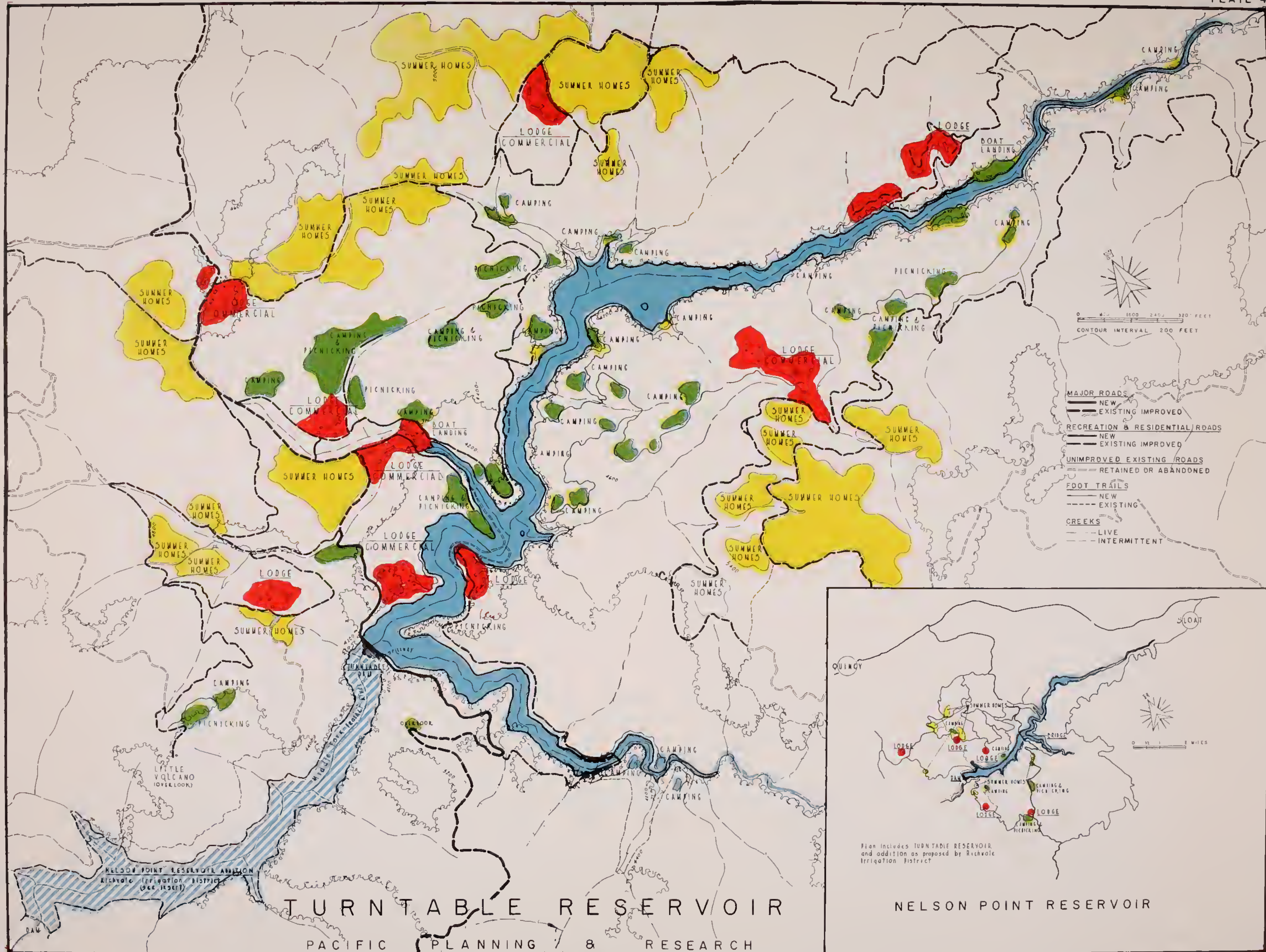
PLATE 2

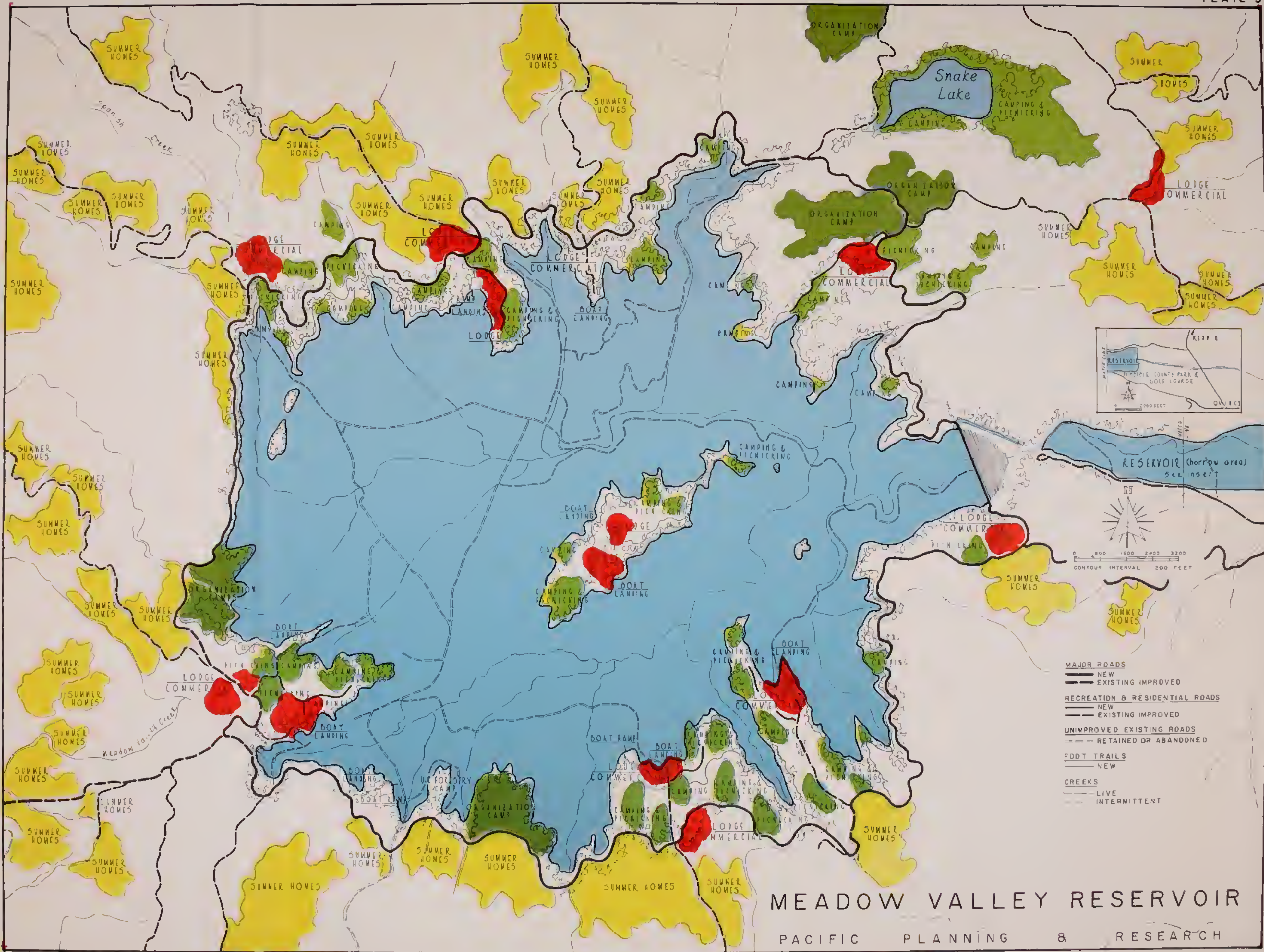

SQUAW QUEEN RESERVOIR
PACIFIC PLANNING & RESEARCH
MAJOR ROADS
NEW
EXISTING IMPROVED
RECREATION & RESIDENTIAL ROADS
NEW
EXISTING IMPROVED
UNIMPROVED EXISTING ROADS
RETAINED OR ABANDONED
FOOT TRAILS
NEW
EXISTING
CREEKS
LIVE
INTERMITTENT
0 1000 2000 3000 4000 FEET
CONTOUR INTERVAL 200 FEET
SUMMER HOMES
LODGE COMMERCIAL
CAMPING PICNICKING
CAMPING & PICNICKING
ORGANIZATION CAMP
BOAT LANDING
BOAT RAMP
COMMERCIAL
Squaw Queen Creek
Last Chance Creek



SHEEP CAMP RESERVOIR

PACIFIC PLANNING & RESEARCH


TURNTABLE RESERVOIR
PACIFIC PLANNING & RESEARCH
NELSON POINT RESERVOIR
MAJOR ROADS
NEW
EXISTING IMPROVED
RECREATION & RESIDENTIAL ROADS
NEW
EXISTING IMPROVED
UNIMPROVED EXISTING ROADS
RETAINED OR ABANDONED
FOOT TRAILS
NEW
EXISTING
CREEKS
LIVE
INTERMITTENT
CONTOUR INTERVAL 200 FEET
SUMMER HOMES
LODGE
COMMERCIAL
CAMPING
PICNICKING
CAMPING & PICNICKING
BOAT LANDING
TURNTABLE DAM
LITTLE VOLCANO (OVERLOOK)
OVERLOOK
NELSON POINT RESERVOIR ADDITION Richvale Irrigation District (see inset)
QUINCY
BRIDGE
Plan includes TURNTABLE RESERVOIR and addition as proposed by Richvale Irrigation District


MEADOW VALLEY RESERVOIR
PACIFIC PLANNING & RESEARCH
Snake Lake
RESERVOIR (borrow area)
See insert
MAJOR ROADS
NEW
EXISTING IMPROVED
RECREATION & RESIDENTIAL ROADS
NEW
EXISTING IMPROVED
UNIMPROVED EXISTING ROADS
RETAINED OR ABANDONED
FOOT TRAILS
NEW
CREEKS
LIVE
INTERMITTENT
0 800 1600 2400 3200
CONTOUR INTERVAL 200 FEET
SUMMER HOMES
ORGANIZATION CAMP
CAMPING & PICNICKING
LODGE COMMERCIAL
BOAT LANDING
BOAT RAMP
U.C. FORESTRY CAMP
Meadow Valley Creek
Spanish Creek

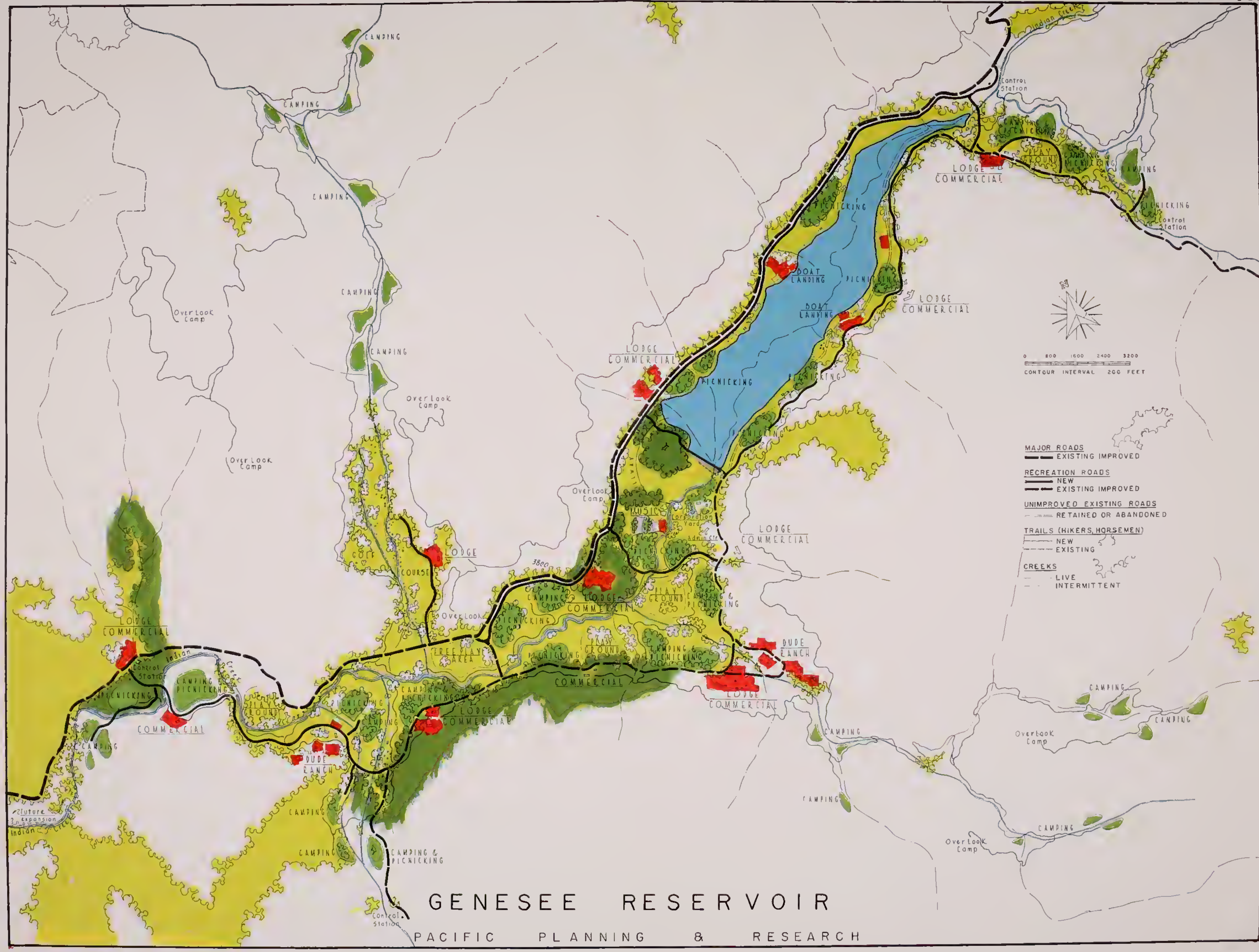
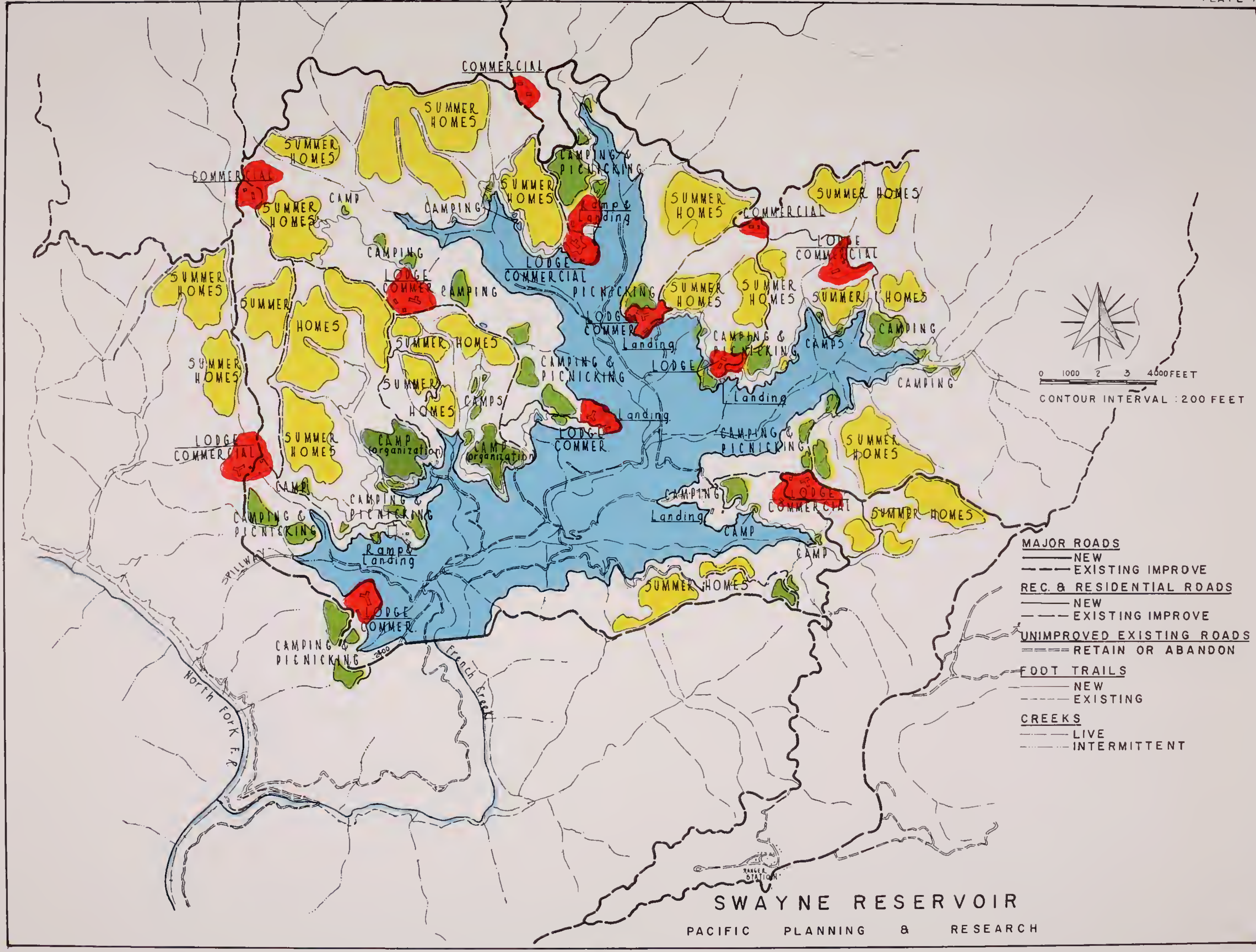
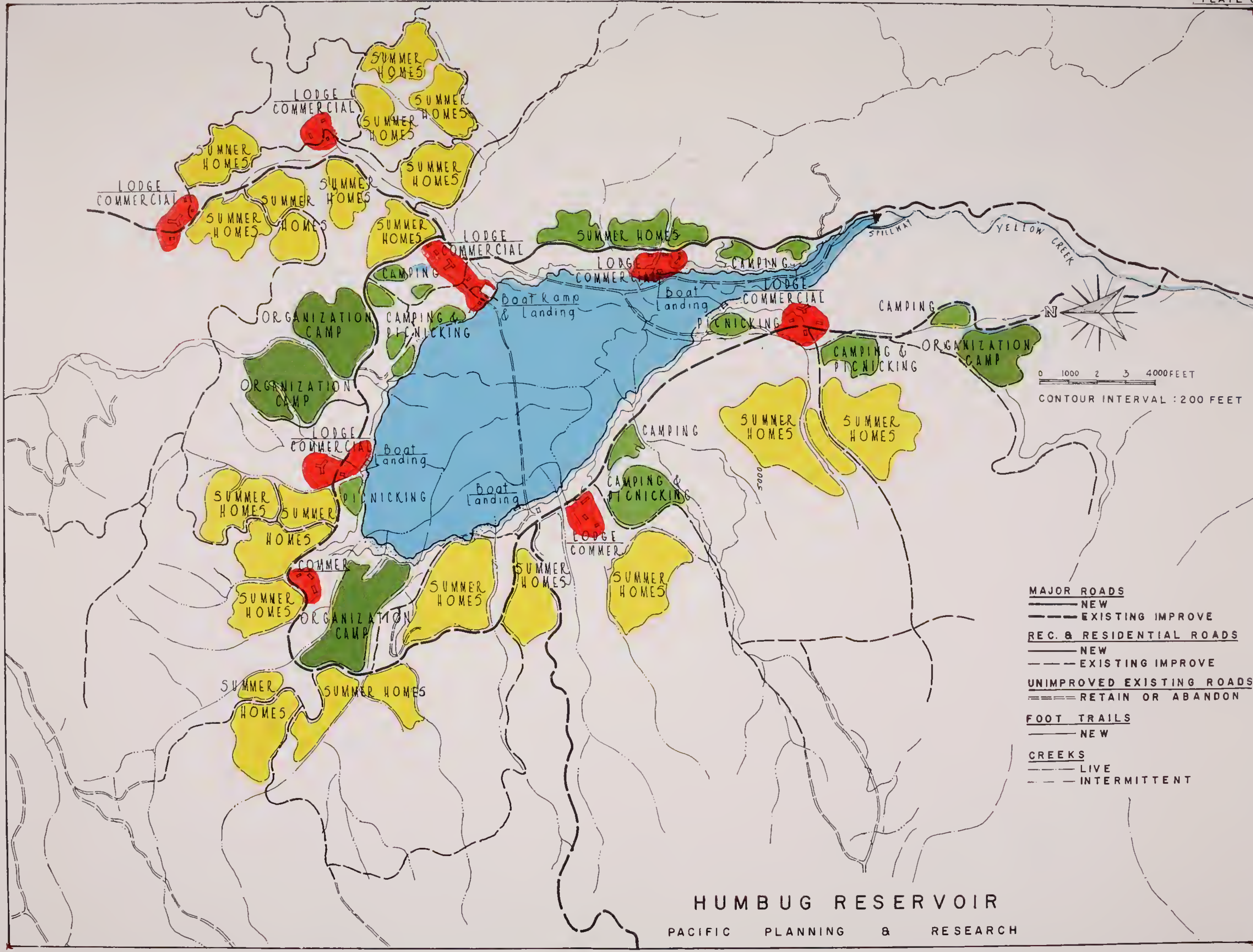

GENESEE RESERVOIR
PACIFIC PLANNING & RESEARCH
MAJOR ROADS
EXISTING IMPROVED
RECREATION ROADS
NEW
EXISTING IMPROVED
UNIMPROVED EXISTING ROADS
RETAINED OR ABANDONED
TRAILS (HIKERS, HORSEMEN)
NEW
EXISTING
CREEKS
LIVE
INTERMITTENT
0 800 1600 2400 3200
CONTOUR INTERVAL 200 FEET
N
LODGE COMMERCIAL
BOAT LANDING
PICNICKING
CAMPING
CAMPING & PICNICKING
PLAY GROUND
FREE PLAY AREA
GOLF COURSE
LODGE
DUDE RANCH
COMMERCIAL
Control Station
Over Look Camp
Corporation Yard
Admin Ctr
Indian Creek
Future expansion
3800

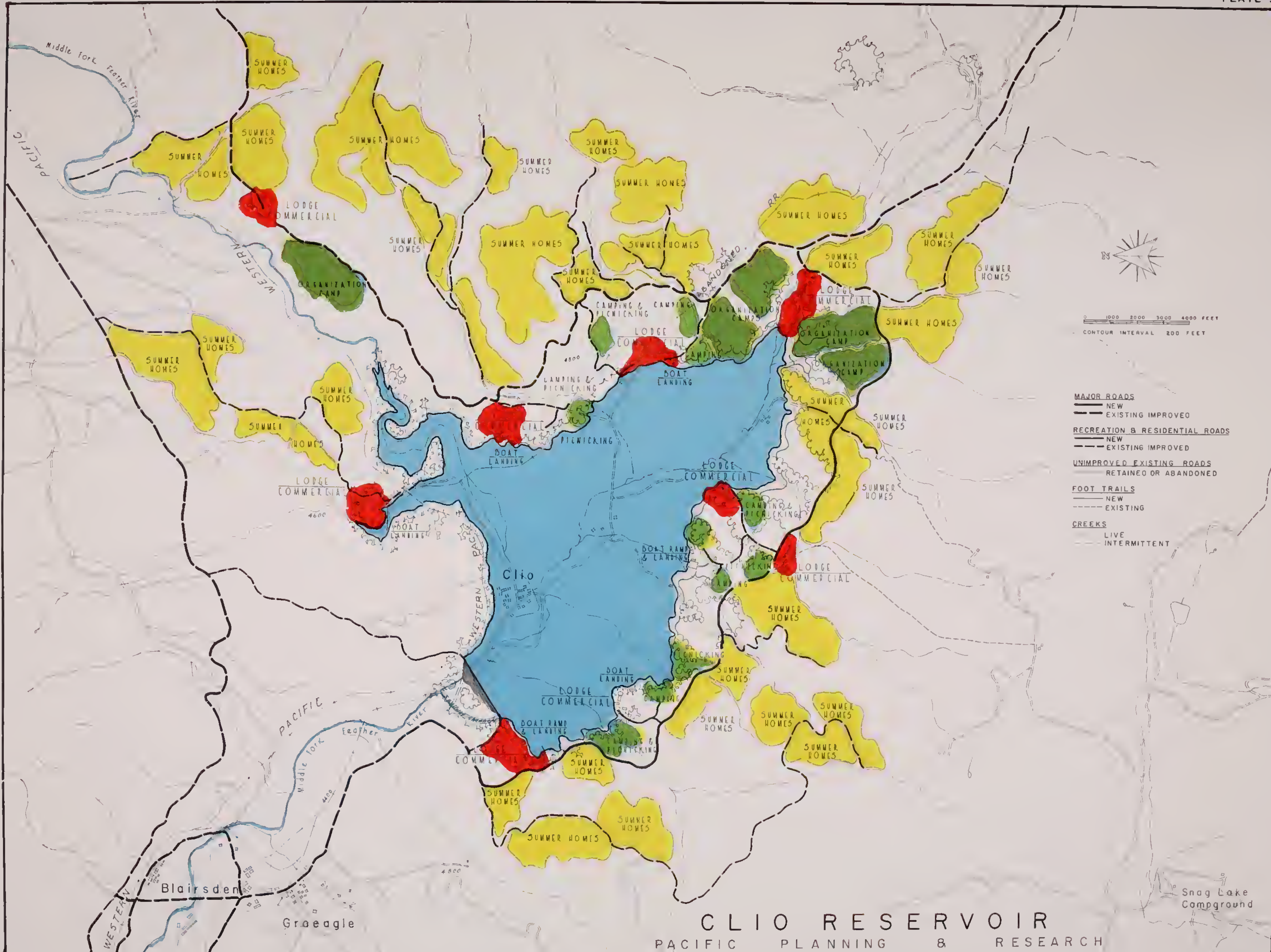
PLATE 7


SWAYNE RESERVOIR
PACIFIC PLANNING & RESEARCH
CONTOUR INTERVAL : 200 FEET
0 1000 2 3 4000 FEET
MAJOR ROADS
NEW
EXISTING IMPROVE
REC. & RESIDENTIAL ROADS
NEW
EXISTING IMPROVE
UNIMPROVED EXISTING ROADS
RETAIN OR ABANDON
FOOT TRAILS
NEW
EXISTING
CREEKS
LIVE
INTERMITTENT
COMMERCIAL
SUMMER HOMES
LODGE COMMERCIAL
CAMPING & PICNICKING
CAMPING
CAMP
CAMPS
CAMP (organization)
Ramp & Landing
Landing
LODGE
SPILLWAY
North Fork F.R.
French Creek
RANGER STATION



HUMBUG RESERVOIR

PACIFIC PLANNING & RESEARCH



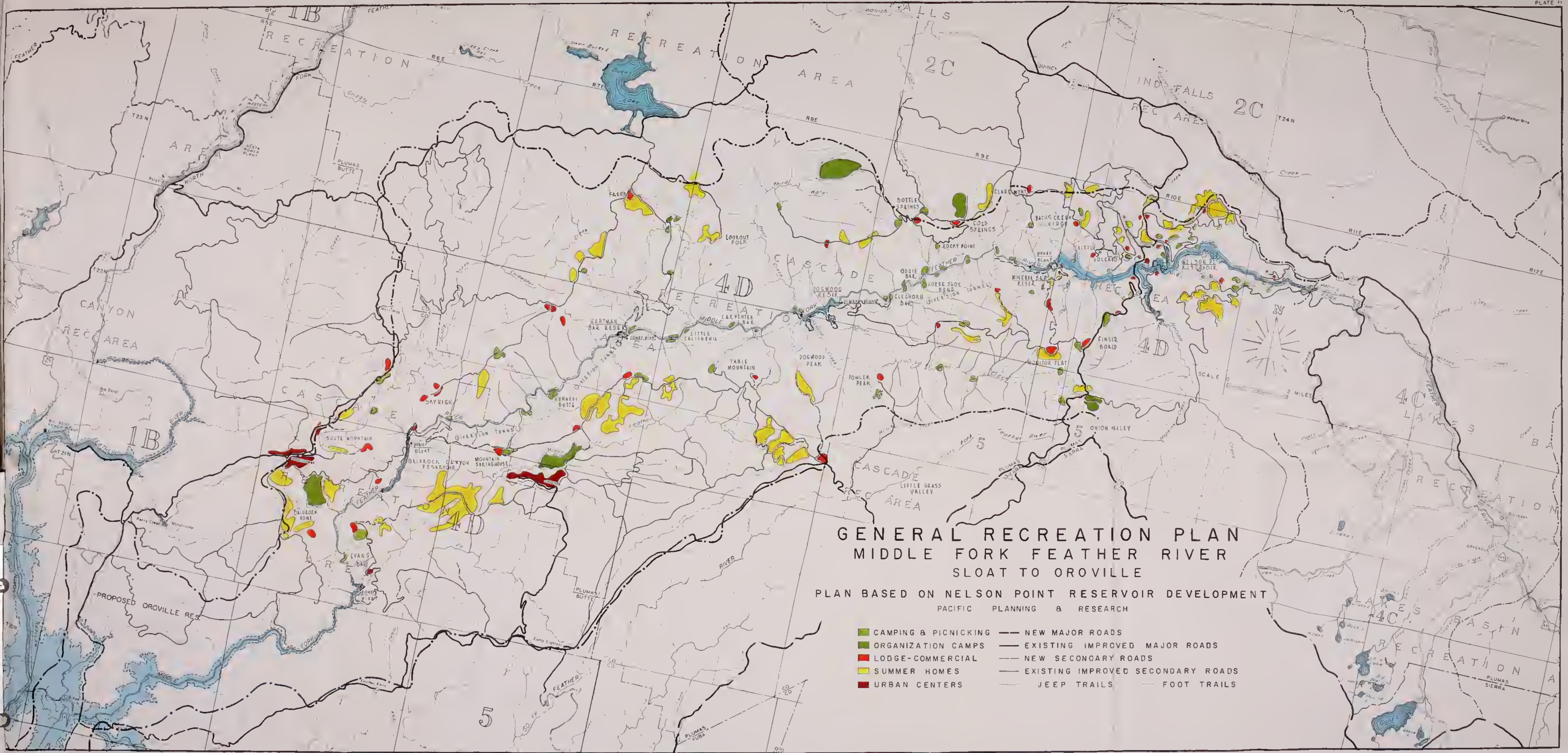
CLIO RESERVOIR

PACIFIC PLANNING & RESEARCH

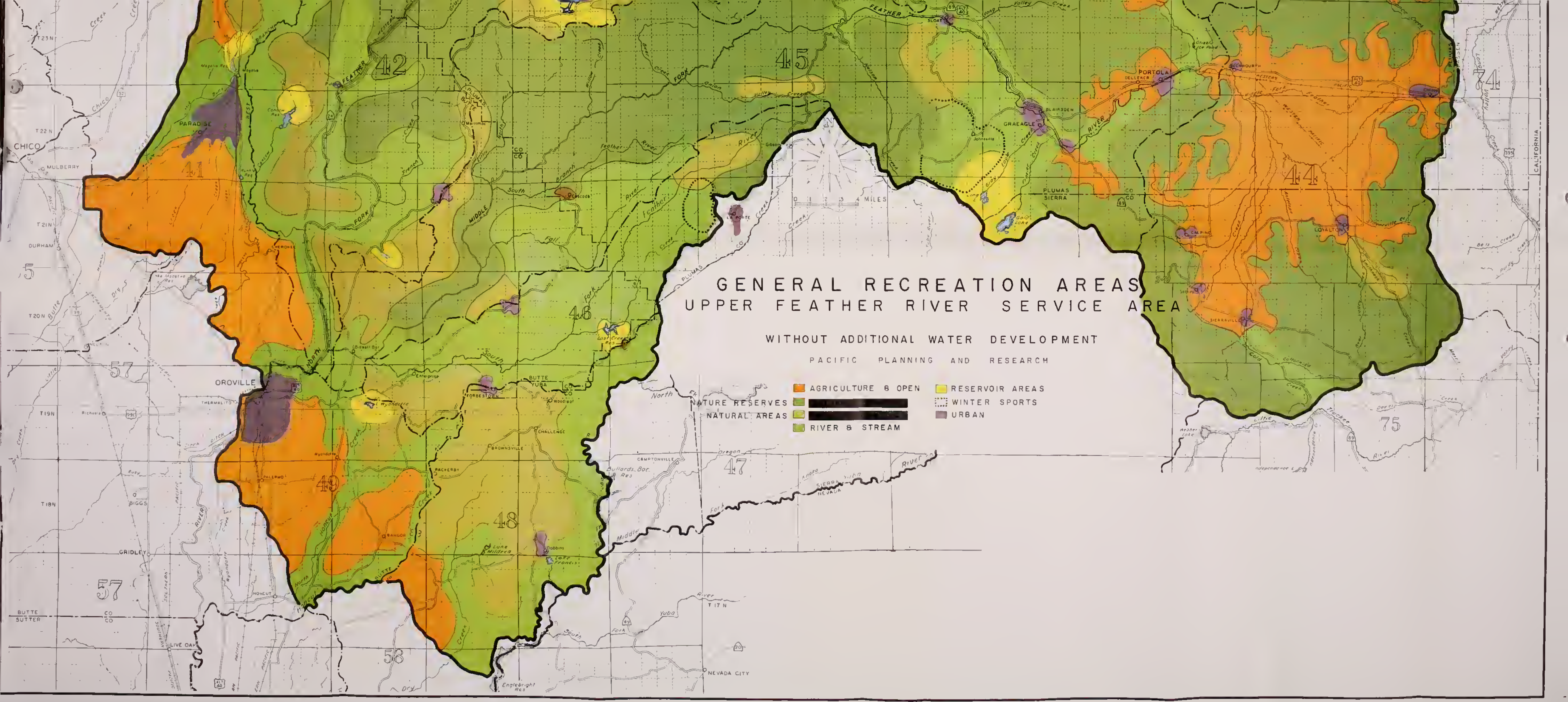
PLATE 10

GENERAL RECREATION PLAN
MIDDLE FORK FEATHER RIVER
SLOAT TO OROVILLE
PLAN BASED ON TURNTABLE RESERVOIR DEVELOPMENT
PACIFIC PLANNING & RESEARCH
CAMPING & PICNICKING
ORGANIZATION CAMPS
LODGE-COMMERCIAL
SUMMER HOMES
URBAN CENTERS
NEW MAJOR ROADS
EXISTING IMPROVED MAJOR ROADS
NEW SECONDARY ROADS
EXISTING IMPROVED SECONDARY ROADS
JEEP TRAILS
FOOT TRAILS
SCALE
2 MILES
N
MEADOW VALLEY RESERVOIR
BUCKS LAKE
SWAYNE RESERVOIR
PROPOSED OROVILLE RES
TURNTABLE RESERVOIR
RECREATION AREA
CASCADE RECREATION AREA
CANYON REC AREA
LAKES BASIN RECREATION AREA
1B
2C
4D
4C
5
FAGGS
LOOKOUT ROCK
BOTTLE SPRINGS
COLD SPRINGS
ROCKY POINT
CLARE MONT
BACHS CREEK RIDGE
LITTLE VOLCANO
MINERVA BAR
RICH BAR
ODBIE BAR
HORSE SHOE BEND
CLEGHORN BAR
HARTMAN BAR
CARPENTER BAR
LITTLE CALIFORNIA
TABLE MOUNTAIN
DOGWOOD PEAK
FOWLER PEAK
MONITOR FLAT
GINGER BOARD
ONION VALLEY
LITTLE GRASS VALLEY
SKYRICK
KENNEDY BUTTE
SUGAR MOUNTAIN
MOUNTAIN SPRINGHOUSE
AMERICAN BAR
BALD ROCK DOME
EVANS BAR
PLUMAS BUTTE
CRESTA POWER PLANT
QUINCY
DIVERSION TUNNEL
MIDDLE FORK FEATHER RIVER
SOUTH FORK FEATHER RIVER
NORTH FORK
WEST BRANCH
PLUMAS SIERRA
PLUMAS YUBA
R6E
R7E
R8E
R9E
R11E
R12E
T21N
T22N
T23N

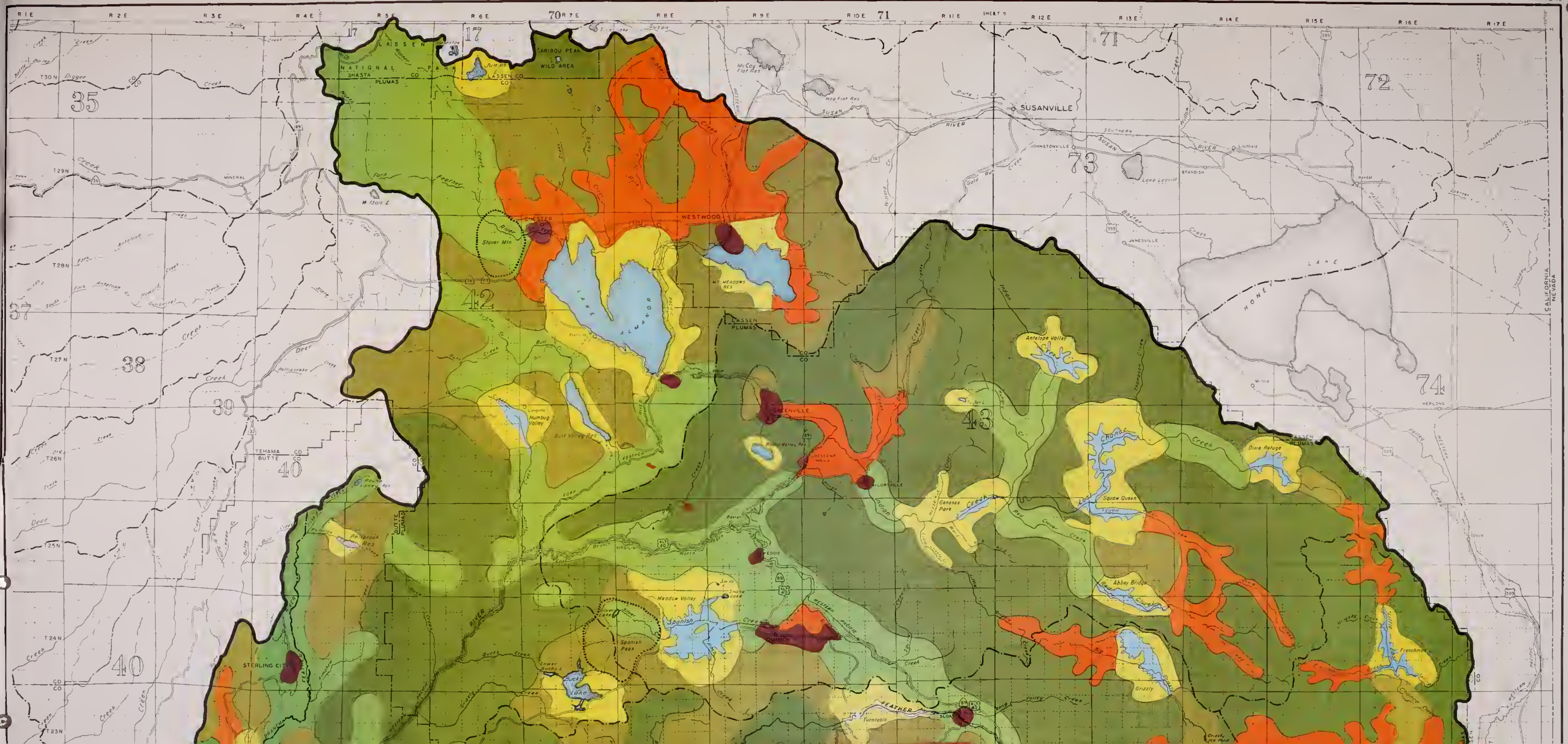
PLATE 11


GENERAL RECREATION PLAN
MIDDLE FORK FEATHER RIVER
SLOAT TO OROVILLE
PLAN BASED ON NELSON POINT RESERVOIR DEVELOPMENT
PACIFIC PLANNING & RESEARCH
CAMPING & PICNICKING
ORGANIZATION CAMPS
LODGE-COMMERCIAL
SUMMER HOMES
URBAN CENTERS
NEW MAJOR ROADS
EXISTING IMPROVED MAJOR ROADS
NEW SECONDARY ROADS
EXISTING IMPROVED SECONDARY ROADS
JEEP TRAILS
FOOT TRAILS
SCALE
2 MILES
RECREATION AREA
2C
4D
4C
1B
5
CANYON REC AREA
CASCADE REC AREA
LAKES BASIN RECREATION AREA
PROPOSED OROVILLE RES
NELSON PT RESERVOIR
BALDROCK CANYON RESERVOIR
DOGWOOD RESER
HARTMAN BAR RESER
TABLE MOUNTAIN
DOGWOOD PEAK
FOWLER PEAK
LOOKOUT ROCK
BOTTLE SPRINGS
COLD SPRINGS
ROCKY POINT
CLARE MONT
BICHS CREEK RIDGE
LITTLE VOLCANO
MINERVA BAR RESER
FINGER BOARD
MOHAWK FLAT
ONION VALLEY
LITTLE GRASS VALLEY
LITTLE CALIFORNIA
CARPENTER BAR
CLEGHORN BAR
HORSE SHOE BEND
ODDIE BAR
KENNEDY BUTTE
SKY HIGH
SOUTE MOUNTAIN
MOUNTAIN SPRINGHOUSE
DIVERSION TUNNEL
POWER PLANT
BALDROCK DOME
EVANS BAR
PLUMAS BUTTE
PLUMAS SIERRA
PLUMAS YUBA
QUINCY
T23N
T22N
T21N
T24N
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E

R 1 E
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
SHEET 9
R 12 E
R 13 E
R 14 E
R 15 E
R 16 E
R 17 E
T30N
T29N
T28N
T27N
T26N
T25N
T24N
T23N
35
37
38
39
40
42
43
70
71
72
73
74
17
LASSEN NATIONAL PARK
SHASTA CO
PLUMAS CO
LASSEN CO
McCoy Flat Res.
Hog Flat Res.
SUSANVILLE
SUSAN RIVER
JOHNSTONVILLE
STANDISH
Lake Leavitt
JANESVILLE
HONEY LAKE
HERLONG
CALIFORNIA
NEVADA
CHESTER
WESTWOOD
LAKE ALMANOR
MT. MEADOWS RES
LASSEN PLUMAS CO CO
Wilson L.
Butt Valley Res
Longville
GREENVILLE
Round Valley Res
CRESCENT MILLS
TAYLORSVILLE
TEHAMA CO
BUTTE CO
Philbrook Res.
BUTTE PLUMAS
STERLING CITY
QUINCY
Spanish
Lower Bucks Lake
Bucks Lake
FEATHER
RIVER
Indian Creek
Chance
Red Clover Creek
Grizzly



GENERAL RECREATION AREAS
UPPER FEATHER RIVER SERVICE AREA
WITHOUT ADDITIONAL WATER DEVELOPMENT
PACIFIC PLANNING AND RESEARCH
AGRICULTURE & OPEN
NATURE RESERVES [redacted]
NATURAL AREAS [redacted]
RIVER & STREAM
RESERVOIR AREAS
WINTER SPORTS
URBAN
0 1 2 3 4 MILES
CHICO
MULBERRY
DURHAM
PARADISE
OROVILLE
THERMALITO
BIGGS
GRIDLEY
HONCUT
LIVE OAK
BUTTE
SUTTER
PORTOLA
BLAIRSDEN
GRAEAGLE
LOYALTON
SIERRAVILLE
CALPINE
CHALLENGE
BROWNSVILLE
NEVADA CITY
PLUMAS
SIERRA
CALIFORNIA
41
42
44
45
46
47
48
49
57
58
74
75


LASSEN NATIONAL PARK
CARIBOU PEAK WILD AREA
SUSANVILLE
CHESTER
WESTWOOD
LAKE ALMANOR
Mt MEADOWS RES
GREENVILLE
Antelope Valley
Humbug Valley
Butt Valley Res
Genesee Park
Squaw Queen
Dixie Refuge
Abbey Bridge
Meadow Valley
Spanish Creek
QUINCY
Bucks Lake
Spanish Peak
STERLING CITY
Philbrook Res
Frenchman
Grizzly
Turntable
FEATHER RIVER
HONEY LAKE
JOHNSTONVILLE
JANESVILLE
STANDISH
Lake Leavitt
McCoy Flat Res
TEHAMA BUTTE CO
BUTTE PLUMAS
LASSEN PLUMAS CO
SHASTA PLUMAS CO
CALIFORNIA NEVADA
R 1 E
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
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R 15 E
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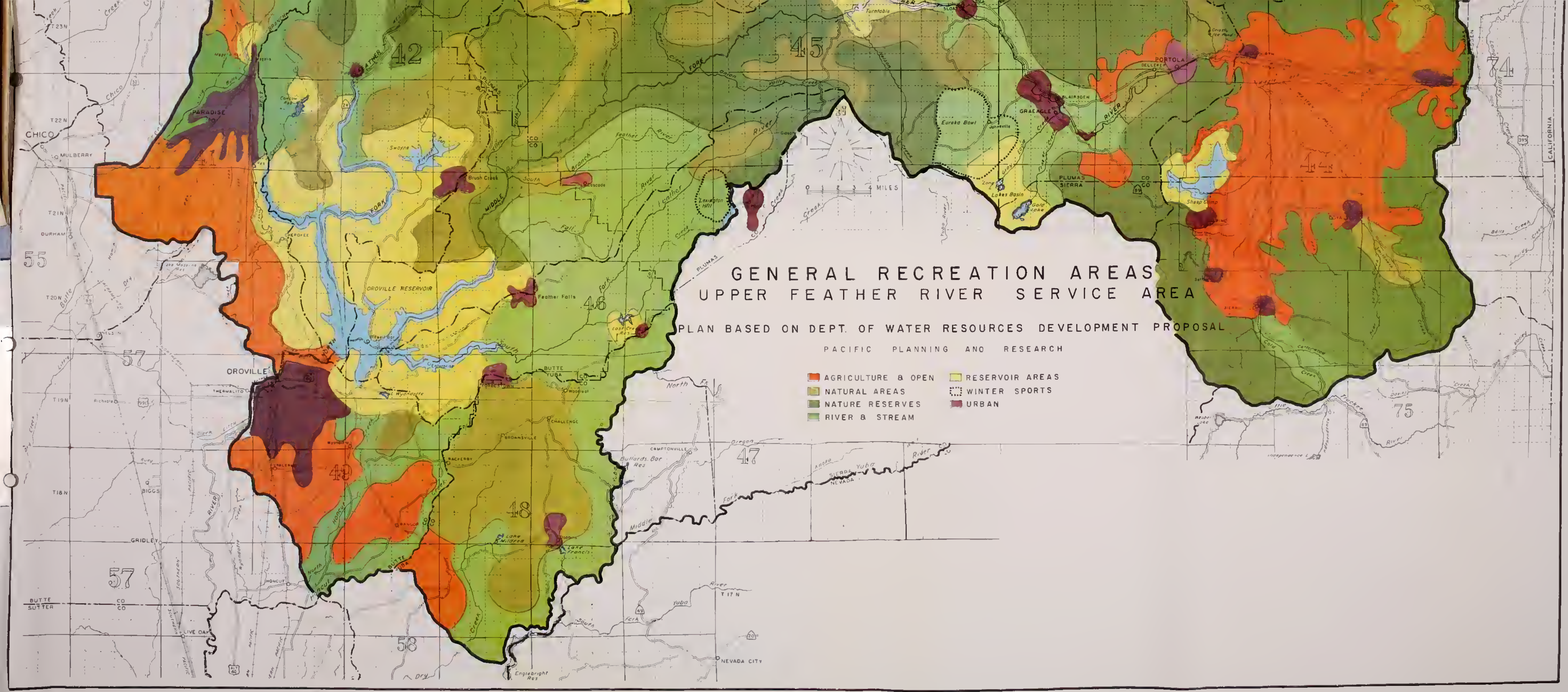
GENERAL RECREATION AREAS
UPPER FEATHER RIVER SERVICE AREA
PLAN BASED ON DEPT. OF WATER RESOURCES DEVELOPMENT PROPOSAL
PACIFIC PLANNING AND RESEARCH
AGRICULTURE & OPEN
NATURAL AREAS
NATURE RESERVES
RIVER & STREAM
RESERVOIR AREAS
WINTER SPORTS
URBAN
MILES
OROVILLE RESERVOIR
OROVILLE
CHICO
PARADISE
PORTOLA
Feather Falls
NEVADA CITY
GRIDLEY
BIGGS
LIVE OAK

APPENDIX B

SUMMARY OF

PROJECT YIELD STUDIES

TABLE OF CONTENTS

SUMMARY OF MONTHLY YIELD STUDY
MODIFIED RICHVALE PROJECT
(Water, in acre-feet -- Energy, in 1,000 kilowatt-hours)

Storage capacity: Clio Reservoir . . . . 100,000 acre-feet
Nelson Point Reservoir . . . . 116,000 acre-feet
Dependable capacity of entire system . . . . . . 123,900 kilowatts

Water year	Clio Reservoir						Nelson Point Reservoir							Power Plant No. 2		Power Plant No. 3		Power Plant No. 4		Power Plant No. 5	
	Inflow	Storage Oct. 1	Evaporation	Fish release	Release to Nelson Point Reservoir	Spill	Inflow	Storage Oct. 1	Evaporation	Fish release	Power Plant No. 1 power release	Spill	Power Plant No. 1 energy	Power release	Energy	Power release	Energy	Power release	Energy	Power release	Energy
1920-21	152,400	83,800	6,300	14,400	25,700	103,300	516,500	70,400	3,200	39,600	251,100	207,900	75,036	307,000	168,227	377,100	185,557	472,800	267,520	522,300	291,411
22	224,500	86,500	6,300	14,400	20,500	169,900	687,300	85,200	3,300	39,600	173,100	468,800	51,449	205,700	112,628	281,000	138,168	372,500	210,711	448,100	249,912
23	137,400	100,000	6,300	14,400	24,100	105,800	444,600	87,900	3,200	39,600	237,100	167,400	70,851	279,700	153,324	333,500	164,140	405,400	229,470	466,300	260,238
24	21,900	86,800	3,600	14,400	70,800	0	140,600	85,200	2,700	39,600	146,800	0	39,579	150,300	82,293	182,600	89,775	216,600	122,522	257,700	143,724
1924-25	73,800	19,800	4,900	14,400	24,600	0	228,300	37,000	3,100	39,600	134,900	2,600	35,942	149,000	81,612	244,400	120,254	340,100	192,471	410,900	229,234
26	39,700	49,700	4,300	14,400	47,400	0	264,400	85,200	3,100	39,600	179,600	42,700	52,667	197,000	107,903	279,600	137,551	356,900	201,942	406,000	226,509
27	183,900	23,300	6,100	14,400	12,400	84,900	522,800	84,700	3,200	39,600	232,700	247,000	69,590	281,100	153,987	357,300	175,760	461,100	260,855	528,100	294,625
28	108,800	89,500	6,300	14,400	37,400	66,600	426,600	85,100	3,200	39,600	182,400	201,200	54,017	214,000	117,320	278,800	137,232	360,300	203,936	436,300	243,454
29	30,800	73,700	4,400	14,400	60,400	0	187,600	85,100	3,200	39,600	146,200	0	42,048	152,900	83,749	212,400	104,464	264,100	149,437	324,800	181,207
1929-30	101,300	25,400	6,100	14,400	27,100	2,900	301,800	84,000	3,200	39,600	219,200	38,700	64,665	251,900	138,001	350,200	172,353	427,600	241,927	458,500	255,795
31	26,800	76,400	4,200	14,400	64,600	0	161,300	85,200	2,900	39,600	136,800	0	38,550	141,200	77,345	179,500	88,284	217,000	122,788	269,100	150,124
32	88,100	20,000	5,800	14,400	17,100	0	284,200	67,200	3,200	39,600	170,200	53,700	48,903	197,600	108,227	279,800	137,623	370,100	209,405	455,500	254,133
33	25,200	70,900	3,500	14,400	58,300	0	180,400	84,900	3,200	39,600	148,300	0	42,744	156,700	85,854	226,800	111,601	288,900	163,519	344,700	192,361
34	26,700	20,000	2,800	14,400	10,500	0	122,300	74,300	2,800	39,600	122,600	0	32,081	131,000	71,763	207,200	101,920	281,700	159,416	360,400	201,083
1934-35	84,200	19,100	5,600	14,400	14,200	0	354,500	31,800	3,000	39,600	174,700	84,200	46,602	205,000	112,300	286,400	140,886	377,200	213,442	460,000	265,651
36	109,500	69,200	6,200	14,400	42,700	32,200	352,900	85,000	3,200	39,600	226,300	83,600	67,209	265,400	145,397	331,000	162,839	417,300	236,069	458,400	255,697
37	79,600	83,300	6,300	14,400	58,300	3,200	288,400	85,100	3,200	39,600	199,600	46,300	58,520	221,400	121,292	270,000	132,815	329,700	186,551	377,000	210,343
38	388,200	80,700	6,300	14,400	11,500	337,300	1,178,000	85,100	3,300	39,600	251,000	874,900	75,503	301,300	165,082	385,300	189,589	485,500	274,692	550,500	307,119
39	28,300	99,500	6,000	14,400	45,000	5,400	166,600	94,400	3,000	39,600	136,300	0	38,972	142,800	78,237	200,500	98,630	257,600	145,783	324,600	181,113
1939-40	211,400	56,900	6,200	14,400	53,600	115,300	565,000	82,000	3,200	39,600	236,600	282,200	70,076	274,100	150,229	324,800	159,845	391,600	221,580	424,000	236,561
41	139,500	79,000	6,300	14,400	14,400	85,500	535,000	85,200	3,200	39,600	264,100	227,900	79,170	319,900	175,389	375,400	184,824	462,200	261,590	508,400	283,723
42	231,500	97,900	6,300	14,400	15,300	193,700	672,100	85,200	3,300	39,600	272,100	353,100	81,629	332,400	182,173	378,800	186,430	465,700	263,495	512,000	285,657
43	319,000	99,800	6,300	14,400	18,100	292,000	772,600	89,400	3,200	39,600	275,800	458,100	82,556	328,900	180,308	374,400	184,319	454,800	257,383	498,500	278,171
44	73,700	88,000	6,300	14,400	42,500	20,400	73,700	85,200	3,200	39,600	173,400	26,000	50,606	188,200	103,157	246,900	121,509	310,200	175,577	380,200	212,160
1944-45	98,500	78,000	6,300	14,400	28,600	43,900	339,500	85,100	3,200	39,600	221,600	75,000	66,171	262,000	143,556	320,500	157,710	410,300	227,068	469,000	261,654
46	142,300	83,500	6,300	14,400	28,600	98,100	440,100	85,200	3,200	39,600	254,700	142,600	75,910	300,400	164,638	350,900	172,706	430,400	243,543	486,300	271,345
47	52,500	78,500	6,200	14,400	40,400	800	220,700	85,100	3,200	39,600	177,500	1,500	52,259	188,300	103,182	253,900	124,931	316,100	178,896	376,800	210,255
48	54,600	69,200	5,800	14,400	25,900	0	271,700	84,100	3,200	39,600	168,200	59,700	49,851	199,900	109,524	266,500	131,099	349,400	197,712	427,900	238,756
49	48,900	77,700	5,800	14,400	47,300	0	166,500	85,200	3,200	39,600	183,900	7,900	48,394	183,900	100,722	243,400	119,729	306,000	173,138	368,600	205,612
1949-50	95,500	59,100	6,100	14,400	47,100	3,400	347,000	84,400	3,200	39,600	224,700	79,100	66,561	263,800	144,469	317,500	156,177	385,600	218,120	427,700	238,557
51	195,400	83,500	6,300	14,400	24,600	155,000	740,800	85,100	3,200	39,600	279,600	418,400	83,686	339,800	186,234	385,600	189,781	472,000	267,066	517,200	288,564
52	530,990	78,600	6,300	14,400	9,200	480,000	1,133,300	85,100	3,300	39,600	283,100	795,100	85,302	340,700	186,717	397,300	195,579	489,000	276,737	532,300	297,038
TOTALS	4,124,800		181,800	460,800	1,068,200	2,399,600	13,087,100		101,000		6,484,200	5,445,600	1,897,099	7,473,300	4,094,839	9,499,300	4,674,080	11,945,700	6,754,361	13,788,100	7,701,786
32-year average	128,900		5,700	14,400	33,400	75,000	409,000		3,200	39,600	202,600	170,200	59,284	233,500	127,960	296,900	146,070	373,300	211,070	430,900	240,680

SUMMARY OF MONTHLY YIELD STUDY
CLIO-NELSON POINT-SWAYNE PROJECT
(Water, in acre-feet -- Energy, in 1,000 kilowatt-hours)

Storage capacity: Clio Reservoir . . . . . 100,000 acre-feet
Nelson Point Reservoir . 116,000 acre-feet
Swayne Reservoir . . . . 280,000 acre-feet
Dependable Capacity of Entire System . . . 174,800 kilowatts

Water year	Clio Reservoir: Inflow	Clio: Storage Oct. 1	Clio: Evaporation	Clio: Fish release	Clio: Release to Nelson Point Reservoir	Clio: Spill	Nelson Point Reservoir and Power Plant No. 1: Total inflow	NP: Storage Oct. 1	NP: Evaporation	NP: Fish release	NP: Release to Power Plant No. 1	NP: Spill	NP: Energy
1920-21	152,400	83,800	6,300	14,400	21,500	101,700	510,700	70,400	3,200	39,600	244,800	206,400	73,369
22	224,500	92,300	6,300	14,400	18,700	177,500	693,100	87,100	3,300	39,600	177,700	468,700	52,783
23	137,400	100,000	6,300	14,400	18,900	107,400	441,100	90,900	3,200	39,600	233,000	168,900	69,840
24	21,900	90,500	3,700	14,400	74,400	0	144,200	87,100	2,900	39,600	137,200	0	37,787
1924-25	73,800	19,800	4,900	14,400	22,100	0	225,800	51,900	3,100	39,600	141,300	6,500	38,518
26	39,700	52,300	4,300	14,400	48,000	0	265,000	87,100	3,100	39,600	179,400	42,700	52,764
27	183,900	25,300	6,100	14,400	8,400	84,900	518,800	87,200	3,200	39,600	228,700	247,000	68,707
28	108,800	95,600	6,300	14,400	32,200	74,700	429,500	87,200	3,200	39,600	183,300	203,500	54,218
29	30,800	76,900	4,700	14,400	52,000	0	179,200	87,200	3,200	39,600	136,600	0	39,280
1929-30	101,300	36,600	6,100	14,400	30,300	4,100	306,200	87,200	3,200	39,600	223,700	39,900	66,609
31	26,800	83,100	4,400	14,400	71,000	0	167,700	87,200	3,000	39,600	132,700	0	37,628
32	88,100	20,000	5,800	14,400	14,000	0	281,100	79,700	3,200	39,600	177,200	53,700	51,310
33	25,200	74,000	3,600	14,400	61,200	0	183,300	87,200	3,200	39,600	143,300	0	41,437
34	26,700	20,000	2,800	14,400	10,500	0	122,300	84,600	2,800	39,600	125,600	0	35,721
1934-35	84,200	19,100	5,600	14,400	7,500	0	347,800	39,100	2,900	39,600	172,900	0	45,383
36	109,500	76,000	6,300	14,400	37,600	40,800	356,300	87,200	3,200	39,600	221,200	92,200	65,946
37	79,600	86,500	6,300	14,400	50,800	9,800	287,500	87,200	3,200	39,600	192,000	52,800	56,489
38	388,200	84,800	6,300	14,400	10,000	342,900	1,182,100	87,200	3,300	39,600	248,200	879,100	74,747
39	28,310	99,500	6,000	14,400	38,800	5,900	160,900	99,000	3,100	39,600	130,000	0	37,433
1939-40	211,400	62,400	6,200	14,400	41,400	126,400	563,900	87,200	3,200	39,600	227,800	293,400	67,822
41	139,500	85,400	6,300	14,400	16,100	91,600	542,800	87,100	3,200	39,600	266,000	234,000	79,753
42	231,500	96,500	6,300	14,400	14,700	192,900	670,700	87,100	3,300	39,600	269,500	353,700	80,962
43	319,000	99,800	6,300	14,400	13,800	294,300	770,600	91,800	3,200	39,600	270,700	461,800	81,171
44	73,700	90,000	6,300	14,400	36,400	23,900	239,500	87,200	3,200	39,600	170,700	26,000	49,845
1944-45	98,500	82,800	6,300	14,400	24,200	50,700	341,900	87,200	3,200	39,600	221,300	77,800	66,156
46	142,300	85,700	6,300	14,400	23,200	100,400	437,000	87,200	3,200	39,600	249,800	144,400	74,581
47	52,500	83,800	6,200	14,400	33,300	8,300	221,100	87,200	3,200	39,600	175,700	2,700	51,860
48	54,600	74,000	5,900	14,400	28,200	0	274,000	87,200	3,200	39,600	177,100	54,200	52,409
49	48,900	80,100	5,900	14,400	44,000	0	212,800	87,100	3,200	39,600	162,200	7,900	47,266
1949-50	95,500	64,800	6,200	14,400	38,900	13,500	348,900	87,200	3,200	39,600	217,200	89,100	64,586
51	195,400	87,200	6,300	14,400	22,100	157,000	740,300	87,200	3,200	39,600	275,400	157,000	82,616
52	530,900	82,900	6,300	14,400	9,100	484,400	1,137,600	87,200	3,300	39,600	281,600	799,400	84,899
TOTALS	3,593,910		182,900		973,300	2,493,100	13,303,700		98,000	1,267,200	6,393,800	5,108,600	1,883,890
32-year average	112,300		5,700	14,400	30,400	77,900	415,700		3,100	39,600	199,800	159,600	58,870

Water year	Power Plant No. 2: Release to Power Plant No. 2	PP No. 2: Energy	Power Plant No. 3: Release to Power Plant No. 3	PP No. 3: Energy	Swayne Reservoir and Power Plant: Total inflow	Swayne: Storage Oct. 1	Swayne: Evaporation	Swayne: Release to Swayne Power Plant	Swayne: Spill	Swayne: Energy
1920-21	300,200	164,915	424,000	171,747	676,180	227,903	6,104	672,771	8,806	814,666
22	209,700	115,220	312,000	126,391	525,020	216,403	6,130	492,905	14,184	594,994
23	276,800	152,042	360,600	146,068	532,420	228,203	6,064	519,849	19,393	629,873
24	140,700	77,213	173,000	700,421	249,600	215,317	3,850	401,825	0	464,094
1924-25	159,300	87,497	260,000	105,350	467,320	59,242	4,031	417,582	0	464,093
26	196,700	108,046	289,900	117,434	473,760	104,949	5,322	399,650	0	464,093
27	276,700	152,037	397,400	160,994	651,120	173,737	5,999	580,265	43,276	701,416
28	214,400	117,713	306,500	124,114	509,500	213,217	5,952	502,097	11,833	605,953
29	143,300	78,634	202,800	82,106	333,400	202,835	4,864	395,579	0	464,091
1929-30	256,200	140,672	379,800	153,828	580,140	135,792	5,857	496,207	11,033	593,430
31	137,100	75,271	175,400	71,039	272,900	202,935	4,003	375,150	0	464,096
32	204,400	112,226	310,000	125,524	511,620	70,518	4,919	407,495	0	464,091
33	151,700	83,238	227,300	92,023	365,040	169,724	4,522	401,144	0	464,093
34	134,000	73,524	210,200	85,100	369,200	129,098	4,184	404,545	0	464,090
1934-35	203,000	111,473	315,500	127,768	514,720	89,569	5,406	401,149	0	464,086
36	260,000	142,845	361,200	146,333	585,180	197,734	6,049	535,583	25,273	646,366
37	213,600	117,261	280,300	113,497	435,960	216,009	5,981	431,537	0	517,297
38	297,900	163,691	435,600	176,463	715,460	214,451	6,115	640,834	55,553	776,025
39	136,500	74,968	194,200	78,673	318,100	227,409	5,240	390,899	0	464,091
1939-40	265,000	145,563	351,300	142,304	579,480	149,370	5,868	504,147	15,633	602,697
41	321,300	176,452	438,100	177,432	672,880	203,202	6,099	601,285	42,885	728,163
42	329,300	180,830	438,600	177,611	680,400	225,813	6,148	635,557	36,305	770,201
43	323,300	177,584	422,800	171,265	656,140	228,203	6,091	623,143	36,273	754,637
44	185,400	101,718	253,300	102,534	407,640	218,836	5,965	407,694	0	488,724
1944-45	261,300	143,523	355,400	143,958	553,620	212,817	6,067	522,348	20,813	631,956
46	295,000	162,031	391,200	158,461	587,580	217,209	6,052	562,227	23,993	680,141
47	187,700	103,027	267,400	108,259	414,800	212,517	5,888	425,264	0	510,688
48	208,200	114,406	301,800	122,267	488,420	196,165	6,045	452,725	4,787	544,356
49	179,500	98,534	258,600	104,729	399,980	221,028	5,907	413,166	0	495,226
1949-50	255,900	140,483	351,200	142,190	537,720	201,935	6,041	498,050	20,613	599,850
51	335,100	184,090	443,800	179,773	688,600	214,951	5,138	600,778	21,545	808,449
52	338,700	186,010	449,800	182,168	719,240	207,354	6,127	682,027	10,537	799,106
TOTALS	7,397,900	4,062,737	10,339,000	4,817,824	16,473,140		178,028	15,889,527	422,735	18,935,132
32-year average	231,200	126,960	323,100	150,560	514,790		5,563	496,550	13,210	591,720

SUMMARY OF MONTHLY YIELD STUDY
NELSON POINT-MEADOW VALLEY-NORTH FORK PROJECT

(Water, in acre-feet--Energy, in 1,000 kilowatt-hours)

Storage capacity: Nelson Point Reservoir . . . . . . 116,000 acre-feet
Meadow Valley Reservoir . . . . . . 900,000 acre-feet
Dependable capacity: Meadow Valley Power Plant . . . 118,500 kilowatts

Water year	Nelson Point Reservoir: Inflow[a]	Nelson Point Reservoir: Storage Oct. 1	Nelson Point Reservoir: Evaporation	Nelson Point Reservoir: Fish release	Nelson Point Reservoir: Diversion to Meadow Valley	Nelson Point Reservoir: Spill	Meadow Valley Reservoir: Inflow[b]	Meadow Valley Reservoir: Storage Oct. 1	Meadow Valley Reservoir: Evaporation	Meadow Valley Reservoir: Fish release	Meadow Valley Reservoir: Irrigation release	Meadow Valley Reservoir: Power release	Meadow Valley Reservoir: Spill	Meadow Valley Power Plant energy
1920-21	539,900	71,800	3,500	54,000	438,200	0	641,200	646,300	19,500	7,200	2,400	437,700	20,200	589,928
22	721,400	116,000	3,500	54,000	442,000	222,000	637,700	800,500	18,500	7,200	2,400	428,100	167,300	580,268
23	452,200	116,000	3,300	54,000	394,900	0	489,500	814,500	18,600	7,200	2,400	404,600	75,700	549,348
24	91,700	116,000	3,100	54,000	116,600	0	154,300	795,700	16,100	7,200	2,400	324,400	0	431,817
1924-25	277,500	34,000	2,500	54,000	225,000	0	301,100	599,900	15,400	7,200	2,400	328,600	0	431,767
26	256,700	30,000	2,000	54,000	200,600	0	316,900	547,400	15,300	7,200	2,400	330,600	0	432,150
27	609,400	30,000	3,200	54,000	466,300	0	653,900	509,100	18,100	7,200	2,400	331,400	0	442,680
28	431,400	116,000	3,300	54,000	356,000	18,100	470,300	804,000	18,400	7,200	2,400	422,900	60,500	572,960
29	158,000	116,000	3,300	54,000	143,500	0	189,000	763,000	16,400	7,200	2,400	324,700	0	431,873
1929-30	373,100	73,200	3,300	54,000	273,000	0	418,500	601,300	17,200	7,200	2,400	324,500	0	432,155
31	123,500	116,000	2,200	54,000	155,300	0	195,900	668,700	15,500	7,200	2,400	327,900	0	431,814
32	355,200	28,000	2,500	54,000	296,700	0	404,400	511,700	15,300	7,200	2,400	330,700	0	432,023
33	147,300	30,000	1,300	54,000	93,100	0	152,900	560,600	13,700	7,200	2,400	334,000	0	432,079
34	138,500	29,000	1,300	54,000	86,200	0	138,100	356,000	9,600	7,200	2,400	346,700	0	432,661
1934-35	424,500	26,100	2,100	54,000	364,500	0	501,000	127,900	9,400	7,200	2,400	357,600	0	434,358
36	387,400	30,000	2,300	54,000	331,200	0	427,500	252,600	12,000	7,200	2,400	343,900	0	432,460
37	306,500	30,000	2,300	54,000	250,400	0	348,800	314,600	11,500	7,200	2,400	343,500	0	432,485
38	1,217,400	30,000	3,200	54,000	702,200	371,900	1,016,700	298,700	17,700	7,200	2,400	379,000	73,800	501,201
39	144,500	116,000	3,300	54,000	89,400	0	138,600	835,100	17,300	7,200	2,400	321,900	0	431,974
1939-40	607,500	113,800	3,300	54,000	507,300	40,700	685,200	624,900	18,500	7,200	2,400	406,700	93,400	548,194
41	574,600	116,000	3,300	54,000	574,600	0	718,500	782,200	18,600	7,200	2,400	499,600	170,400	678,932
42	597,400	116,000	3,300	54,000	525,600	14,500	739,300	802,600	18,600	7,200	2,400	513,200	187,800	697,311
43	781,500	116,000	3,300	54,000	642,100	82,100	810,200	812,900	18,600	7,200	2,400	527,900	271,000	717,864
44	252,800	116,000	3,300	54,000	195,500	0	274,500	796,200	17,900	7,200	2,400	320,800	0	432,005
1944-45	365,500	116,000	3,300	54,000	308,200	0	422,300	722,300	18,300	7,200	2,400	325,600	0	439,244
46	455,700	116,000	3,300	54,000	398,400	0	538,500	791,100	18,600	7,200	2,400	464,100	56,300	630,410
47	232,000	116,000	3,300	54,000	175,500	0	249,900	781,300	17,800	7,200	2,400	321,200	0	432,056
48	300,400	115,200	3,300	54,000	242,200	0	366,200	682,500	17,400	7,200	2,400	324,800	0	432,226
49	217,700	116,000	3,300	54,000	173,500	0	255,000	698,000	16,500	7,200	2,400	325,700	0	432,185
1949-50	392,000	102,800	3,300	54,000	321,600	0	466,000	601,400	17,400	7,200	2,400	324,500	0	432,110
51	756,600	116,000	3,300	54,000	583,100	116,200	765,400	696,200	18,400	7,200	2,400	567,100	91,400	770,125
52	1,175,000	116,000	3,300	54,000	655,400	462,200	948,100	772,000	18,800	7,200	2,400	507,100	344,200	689,343
32-year average	433,300		2,900	54,000	335,300	41,500	463,600		16,600	7,200	2,400	380,300	50,500	505,875

a/ Present impaired inflow including operation of Frenchman, Sheep Camp, and Grizzly Valley Reservoirs.
b/ Present impaired inflow including diversions from Nelson Point and Red Ridge Dams.

SUMMARY OF MONTHLY YIELD STUDY
NELSON POINT-MEADOW VALLEY-BALD ROCK PROJECT
(Water, in acre-feet -- Energy, in 1,000 kilowatt-hours)

Storage capacity: Nelson Point Reservoir . . . . 116,000 acre-feet
Meadow Valley Reservoir . . . 900,000 acre-feet
Dependable capacity of entire system: . . . . . 209,000 kilowatts

	Nelson Point Reservoir						Meadow Valley Reservoir and Power Plant								Hartman Bar Power Plant		Bald Rock Power Plant	
Water year	Inflow a/	Storage Oct.1	Evaporation	Fish release	Diversion to Meadow Valley	Spill	Total inflow b/	Storage Oct.1	Evaporation	Fish release	Irrigation release	Power release	Spill	Energy	Power release c/	Energy	Power release c/	Energy
1920-21	539,900	70,000	3,000	54,000	436,600	0	635,000	600,000	18,300	7,200	2,400	386,600	50,900	479,828	681,700	380,457	920,000	513,387
22	721,400	116,000	3,300	54,000	443,400	220,600	639,100	769,500	18,500	7,200	2,400	381,600	194,400	474,965	556,200	310,379	739,400	412,632
23	452,200	116,000	3,300	54,000	394,900	0	489,600	804,200	18,600	7,200	2,400	389,600	105,300	486,000	508,800	283,990	649,900	351,336
24	91,700	116,000	2,800	54,000	122,100	0	159,700	770,800	15,900	7,200	2,400	374,600	0	455,592	433,800	242,028	474,900	264,962
1924-25	277,500	28,800	2,500	54,000	220,000	0	295,900	530,600	14,900	7,200	2,400	305,100	0	365,081	500,100	279,148	641,200	357,882
26	256,700	30,000	2,200	54,000	200,700	0	316,700	496,900	14,700	7,200	2,400	314,100	0	374,989	513,500	286,612	654,400	365,266
27	609,400	30,000	3,200	54,000	396,300	69,900	584,000	475,000	17,400	7,200	2,400	301,400	0	286,203	649,100	362,326	869,500	485,271
28	431,400	116,000	3,300	54,000	360,400	13,700	474,700	730,300	18,200	7,200	2,400	366,500	70,700	455,370	567,000	316,456	732,800	408,933
29	158,000	116,000	3,300	54,000	171,700	0	217,200	740,000	16,300	7,200	2,400	333,100	0	405,776	444,700	248,136	525,700	293,334
1929-30	373,100	45,000	3,200	54,000	244,900	0	390,600	598,200	17,100	7,200	2,400	335,200	0	408,774	611,300	341,200	798,300	445,541
31	123,500	116,000	1,800	54,000	155,600	0	196,200	626,900	15,300	7,200	2,400	351,700	0	423,611	420,700	234,787	472,800	263,859
32	355,200	28,000	2,500	54,000	296,700	0	404,400	446,400	14,900	7,200	2,400	302,300	0	360,091	547,600	305,615	714,200	398,573
33	147,300	30,000	1,500	54,000	92,800	0	152,600	524,100	13,400	7,200	2,400	328,600	0	386,910	469,700	262,068	572,200	319,263
34	138,500	29,000	1,300	54,000	86,200	0	137,900	325,200	9,600	7,200	2,400	336,900	0	381,637	481,600	268,720	584,700	326,250
1934-35	424,500	26,100	2,400	54,000	364,300	0	501,100	106,900	9,800	7,200	2,400	320,800	0	357,136	564,300	314,897	729,000	406,795
36	387,400	30,000	2,500	54,000	315,600	15,400	411,800	267,800	12,400	7,200	2,400	314,800	0	363,094	605,800	338,071	798,900	445,857
37	306,500	30,000	2,500	54,000	250,100	0	348,600	342,800	12,400	7,200	2,400	331,200	0	383,438	499,000	278,482	620,000	345,963
38	1,217,400	30,000	3,200	54,000	668,000	406,200	982,200	338,400	18,000	7,200	2,400	343,000	127,700	419,141	688,100	384,030	938,800	523,878
39	144,500	116,000	3,300	54,000	90,700	0	139,900	822,600	17,300	7,200	2,400	335,600	0	412,851	483,800	270,018	522,300	291,509
1939-40	607,500	112,500	3,300	54,000	507,500	39,200	685,400	600,000	18,100	7,200	2,400	403,600	114,000	499,413	612,500	341,842	765,200	427,048
41	574,600	116,000	3,300	54,000	517,300	0	718,500	740,100	18,500	7,200	2,400	433,300	194,700	552,913	668,400	373,023	907,000	506,150
42	597,400	116,000	3,300	54,000	525,600	14,500	739,300	792,700	18,600	7,200	2,400	443,200	255,000	553,609	685,500	382,573	932,800	520,526
43	781,500	116,000	3,300	54,000	643,300	80,900	811,400	805,700	18,600	7,200	2,400	481,000	332,600	600,898	644,400	359,694	846,600	472,482
44	252,800	116,000	3,300	54,000	195,500	0	274,500	775,500	17,900	7,200	2,400	322,000	0	397,306	473,300	264,142	579,400	323,308
1944-45	365,500	116,000	3,300	54,000	308,200	0	422,300	700,800	18,400	7,200	2,400	325,400	0	403,497	554,500	309,523	723,500	403,792
46	455,700	116,000	3,300	54,000	398,400	0	538,500	769,900	18,600	7,200	2,400	426,900	98,600	532,692	636,800	355,373	819,500	457,248
47	232,000	116,000	3,300	54,000	175,500	0	249,900	755,000	17,700	7,200	2,400	326,600	0	402,495	480,800	268,343	591,700	330,226
48	300,400	115,200	3,300	54,000	242,200	0	366,300	650,800	17,600	7,200	2,400	284,100	0	348,126	537,700	300,080	705,900	393,931
49	217,700	116,000	3,300	54,000	161,500	0	243,000	706,100	16,800	7,200	2,400	322,700	0	394,035	511,300	285,376	635,500	354,674
1949-50	392,000	114,800	3,300	54,000	333,500	0	457,900	600,000	17,600	7,200	2,400	317,800	0	389,741	564,200	314,866	731,400	408,159
51	756,600	116,000	3,300	54,000	579,600	119,700	761,900	713,000	18,400	7,200	2,400	498,800	197,500	622,980	692,300	386,449	924,900	516,136
52	1,175,000	116,000	3,300	54,000	655,400	462,200	948,100	750,000	18,800	7,200	2,400	441,100	400,300	551,185	627,300	350,096	850,200	474,471
TOTALS	13,864,800		94,300		10,554,500	1,442,300	14,694,200		528,600			11,479,200	2,141,700	14,011,377	17,915,800	9,998,800	22,972,600	12,808,642
32-year average	433,300		2,900	54,000	329,800	45,100	459,200		16,500	7,200	2,400	358,700	66,900	437,860	559,900	312,460	717,900	400,270

a/ Present impaired inflow including operation of Frenchman, Sheep Camp, and Grizzly Valley Reservoirs.
b/ Present impaired inflow including diversions from Nelson Point and Red Ridge Dams.
c/ Present impaired inflow including spill from Nelson Point Reservoir.

SUMMARY OF MONTHLY YIELD STUDY
TURNTABLE-MEADOW VALLEY-SWAYNE PROJECT
(Water, in acre-feet -- Energy, in 1,000 kilowatt-hours)

Storage capacity: Turntable Reservoir . . . . 52,000 acre-feet
Meadow Valley Reservoir . . . . . 900,000 acre-feet
Swayne Reservoir . . . . 280,000 acre-feet
System dependable capacity: . . . . 273,000 kilowatts

Water year	Turntable Reservoir						Meadow Valley Reservoir							Swayne Reservoir						
	Inflow	Storage Oct. 1	Evaporation	Fish release	Release to: Meadow Valley Reservoir	Spill	Total inflow	Storage Oct. 1	Evaporation	Fish release	Release to Meadow Valley Power Plant	Spill	Energy	Total inflow	Storage Oct. 1	Evaporation	Fish release	Release to: Swayne Power Plant	Spill	Energy
1919-20	218,000	52,000	2,000	54,000	163,000	0	220,800	790,300	17,900	7,200	330,000	0	392,821	516,200	239,600	5,500	7,200	579,800	0	682,808
21	505,700	51,000	2,000	54,000	448,700	0	644,900	656,000	18,400	7,200	470,800	48,800	561,570	993,300	163,300	6,200	7,200	879,400	24,900	1,057,057
22	694,300	52,000	2,000	54,000	537,100	101,200	730,100	755,700	18,500	7,200	466,400	238,000	556,550	814,600	238,900	6,300	7,200	776,400	24,700	934,720
23	439,200	52,000	2,000	54,000	383,200	0	475,500	755,700	18,500	7,200	431,500	21,000	515,273	685,900	238,900	6,200	7,200	673,300	0	809,414
24	85,900	52,000	2,000	54,000	32,100	0	67,500	753,000	16,300	7,200	302,800	0	356,720	406,800	238,100	4,200	7,200	564,000	0	647,920
1924-25	261,100	49,800	2,000	54,000	202,900	0	276,500	494,200	15,000	7,200	310,100	0	356,720	639,400	69,500	4,200	7,200	586,900	0	647,920
26	237,500	52,000	2,000	54,000	181,700	0	295,400	438,400	14,300	7,200	313,800	0	356,720	647,300	110,600	5,500	7,200	563,200	0	647,920
27	574,000	51,800	2,000	54,000	517,800	0	703,200	398,500	17,900	7,200	331,600	0	387,894	951,500	182,000	6,000	7,200	885,500	28,000	1,062,395
28	405,400	52,000	2,000	54,000	349,400	0	461,300	745,000	18,400	7,200	401,900	46,200	479,600	777,100	206,800	6,000	7,200	758,400	6,000	908,396
29	147,700	52,000	2,000	54,000	92,900	0	136,000	732,600	16,800	7,200	302,100	0	356,720	489,900	205,500	4,700	7,200	561,900	0	647,920
1929-30	493,800	50,800	2,000	54,000	436,600	0	579,800	542,500	18,200	7,200	348,500	0	412,438	804,300	121,600	6,000	7,200	690,900	0	817,966
31	115,700	52,000	2,000	54,000	62,200	0	100,300	748,400	16,600	7,200	302,200	0	356,720	433,100	221,800	4,300	7,200	564,400	0	647,920
32	332,400	49,500	2,000	54,000	274,100	0	379,300	522,700	16,700	7,200	305,900	0	356,720	703,800	79,000	5,500	7,200	570,500	0	647,920
33	133,300	51,800	2,000	54,000	78,300	0	135,700	572,200	14,100	7,200	311,000	0	356,720	532,100	199,600	5,000	7,200	559,600	0	647,920
34	125,900	50,800	2,000	54,000	73,400	0	122,700	375,600	9,200	7,200	330,400	0	356,720	564,900	159,900	5,200	7,200	559,600	0	647,920
1934-35	398,000	47,300	2,000	54,000	326,800	10,500	461,100	151,500	10,000	7,200	342,900	0	356,720	746,300	153,400	6,000	7,200	667,500	2,900	790,224
36	360,000	52,000	2,000	54,000	304,000	0	397,800	252,500	12,000	7,200	326,700	0	356,720	832,700	216,100	6,100	7,200	808,900	6,800	970,035
37	288,300	52,000	2,000	54,000	232,300	0	328,400	304,400	11,700	7,200	327,100	0	356,720	617,600	219,800	6,000	7,200	606,400	0	721,148
38	1,172,700	52,000	2,000	54,000	829,100	287,600	1,141,000	286,800	17,900	7,200	454,000	186,600	529,391	1,100,300	217,800	6,200	7,200	1,033,900	31,900	1,241,915
39	135,300	52,000	2,000	54,000	81,400	0	128,100	762,100	17,000	7,200	308,100	0	364,867	486,300	238,900	5,400	7,200	560,200	0	659,885
1939-40	577,000	49,900	2,000	54,000	518,900	0	694,400	557,900	18,300	7,200	421,300	60,700	499,611	877,600	152,400	6,100	7,200	783,000	11,000	929,377
41	535,500	52,000	2,000	54,000	479,500	0	777,400	744,800	18,600	7,200	535,500	205,200	639,491	1,017,100	222,700	6,200	7,200	974,500	13,000	1,171,517
42	660,700	52,000	2,000	54,000	604,700	0	816,100	755,700	18,600	7,200	589,200	201,100	703,662	1,084,600	238,900	6,300	7,200	1,057,200	13,900	1,272,371
43	756,600	52,000	2,000	54,000	700,600	0	866,400	755,700	18,500	7,200	550,500	296,200	657,373	962,500	238,900	6,200	7,200	938,700	16,100	1,129,626
44	239,600	52,000	2,000	54,000	183,600	0	260,200	749,700	18,500	6,700	299,600	0	356,720	556,400	233,200	5,900	7,290	569,000	0	677,023
1944-45	343,000	52,000	2,000	54,000	287,000	0	398,700	685,100	18,300	7,200	326,600	0	389,022	759,200	207,500	6,100	7,200	740,500	0	885,631
46	432,300	52,000	2,000	54,000	376,300	0	514,000	731,700	18,500	7,200	448,000	27,000	534,889	831,500	212,900	6,100	7,200	806,900	1,600	964,170
47	217,200	52,000	2,000	54,000	162,000	0	233,700	745,000	17,900	7,200	299,500	0	356,720	559,400	222,600	5,900	7,200	577,400	0	687,484
48	272,600	51,200	2,000	54,000	215,800	0	337,500	654,100	17,700	7,200	301,300	0	356,720	709,400	191,500	6,000	7,200	664,800	2,900	792,168
49	200,500	52,000	2,000	54,000	145,400	0	224,400	665,400	16,900	7,200	302,700	0	356,720	603,900	220,000	6,000	7,200	611,200	0	726,355
1949-50	367,300	51,100	2,000	54,000	310,400	0	432,400	563,000	17,700	7,200	302,800	0	356,720	730,400	199,500	6,000	7,200	695,200	11,300	829,381
51	731,300	52,000	2,000	54,000	611,200	64,100	791,100	667,700	18,400	7,200	570,800	117,000	681,366	1,037,600	210,200	6,100	7,200	1,013,600	3,600	1,214,598
52	1,135,700	52,000	2,000	54,000	755,400	324,300	1,045,800	745,400	18,600	7,200	530,500	464,700	633,552	1,034,900	217,300	6,200	7,200	991,100	8,800	1,192,146
TOTALS	13,593,500		66,000	1,782,000	10,957,800	787,700	15,177,500		551,900	237,100	12,496,100	1,912,500	14,646,890	24,507,900		189,600	237,600	23,873,200	208,200	28,311,170
33-year average	411,900		2,000	54,000	332,100	23,900	459,900		16,700	7,200	378,700	58,000	443,850	742,700		5,700	7,200	723,400	6,300	857,910

SUMMARY OF MONTHLY YIELD STUDY
SHEEP CAMP PROJECT

(In acre-feet)

Storage capacity . . . . 65,000 acre-feet
Seasonal yield . . . . 48,000 acre-feet

Water year	Inflow	Storage October 1	Evaporation	Yield	Spill
1911-12	45,020	46,660	4,630	48,000	3,020
13	47,670	36,030	4,430	48,000	0
14	94,950	31,270	4,680	48,000	31,690
1914-15	59,590	41,850	4,690	48,000	9,100
16	82,290	39,650	4,710	48,000	25,900
17	66,780	43,330	4,710	48,000	15,470
18	48,940	41,930	4,500	48,000	5,350
19	57,340	32,970	4,510	48,000	3,920
1919-20	52,250	33,880	4,450	48,000	0
21	68,730	33,680	4,670	48,000	8,960
22	73,310	40,780	4,700	48,000	16,500
23	63,480	44,890	4,700	48,000	16,160
24	29,580	39,510	4,130	48,000	0
1924-25	48,430	16,960	3,750	48,000	0
26	42,900	13,640	3,370	48,000	0
27	81,530	5,170	4,260	48,000	0
28	57,510	34,440	4,560	48,000	3,930
29	35,470	35,460	4,110	48,000	0
1929-30	62,870	18,820	4,320	48,000	0
31	32,340	29,370	3,800	48,000	0
32	56,500	9,910	3,680	48,000	0
33	37,620	14,730	3,680	24,000	0
34	32,430	24,670	3,590	48,000	0
1934-35	69,100	5,510	3,730	48,000	0
36	59,430	22,880	4,330	48,000	0
37	53,340	29,980	4,400	48,000	0
38	91,040	30,920	4,670	48,000	23,220
39	31,470	46,070	4,430	48,000	0
1939-40	69,680	25,110	4,580	48,000	4,870
41	66,780	37,340	4,660	48,000	10,230
42	80,370	41,230	4,720	48,000	23,740
43	85,900	45,140	4,660	48,000	36,910
44	49,300	41,470	4,620	48,000	3,820

SUMMARY OF MONTHLY YIELD STUDY
SHEEP CAMP PROJECT
(continued)

(In acre-feet)

Water year	Inflow	Storage October 1	Evaporation	Yield	Spill
1944-45	56,200	34,330	4,600	48,000	910
46	67,550	37,020	4,640	48,000	12,580
47	43,090	39,350	4,030	48,000	0
48	45,760	30,410	4,140	48,000	0
49	38,830	24,030	3,730	48,000	0
1949-50	57,030	11,130	3,740	48,000	0
51	77,260	16,420	4,530	48,000	3,060
52	105,730	38,100	4,750	48,000	38,040
53	73,420	52,040	4,760	48,000	24,100
54	47,800	47,600	4,590	48,000	10,110
1954-55	37,210	32,700	4,040	48,000	0
56	101,350	17,870	4,650	48,000	19,910
Average	59,670	---	4,350	47,470	7,850

SUMMARY OF MONTHLY YIELD STUDY
SQUAW QUEEN PROJECT

(Water, in acre-feet -- Energy, in 1,000 kilowatt-hours)

Storage capacity . . . . 100,000 acre-feet
Dependable capacity. . . . . 11,300 kilowatts

	Squaw Queen Reservoir					
Water year	Inflow	Storage, Oct. 1	Evaporation	Release to power plant	Spill	Energy
1911-12	20,500	81,600	6,700	30,600	0	42,920
13	30,900	64,800	6,100	29,900	0	41,720
14	126,900	59,700	7,600	54,500	44,000	76,650
1914-15	57,400	80,500	7,600	42,700	7,300	59,990
16	105,000	80,300	7,700	63,100	34,000	88,700
17	81,600	80,500	7,700	59,100	15,000	83,150
18	33,700	80,300	7,500	29,700	0	41,720
19	55,200	76,800	7,600	43,800	400	61,540
1919-20	18,600	84,200	6,500	29,800	0	41,720
21	87,800	62,500	7,700	48,800	13,200	68,650
22	105,000	80,600	7,800	60,400	36,800	84,930
23	31,100	80,600	7,100	32,800	0	45,980
24	9,500	71,800	5,400	29,900	0	41,720
1924-25	19,700	46,000	4,200	30,200	0	41,720
26	51,200	31,300	5,100	30,100	0	41,720
27	73,700	47,300	7,300	32,900	0	46,030
28	49,400	80,800	7,700	39,100	3,100	54,950
29	12,600	80,300	6,200	29,800	0	41,720
1929-30	52,600	56,900	7,100	29,800	0	41,720
31	11,500	72,600	5,600	29,900	0	41,720
32	37,400	48,600	5,500	30,000	0	41,720
33	17,700	50,500	4,300	30,100	0	41,720
34	13,700	33,800	3,000	30,400	0	41,720
1934-35	55,200	14,100	4,100	30,400	0	41,720
36	42,900	34,800	4,900	30,100	0	41,720
37	38,600	42,700	5,000	30,100	0	41,720
38	164,500	46,200	7,700	53,900	68,900	75,720
39	17,900	80,200	6,500	29,800	0	41,720
1939-40	79,700	61,800	7,600	45,100	8,700	63,360
41	67,200	80,100	7,700	56,900	2,400	80,040
42	89,300	80,300	7,700	66,000	15,600	92,770
43	90,600	80,300	7,800	66,500	16,600	93,490
44	36,600	80,000	7,600	29,700	0	41,720
1944-45	38,700	79,300	7,500	31,500	0	44,290
46	59,700	79,000	7,700	50,700	0	71,280
47	25,700	80,300	6,800	29,800	0	41,720
48	39,000	69,400	6,700	29,800	0	41,720
49	27,100	71,900	6,300	29,800	0	41,720
1949-50	44,500	62,900	6,700	29,800	0	41,720
51	61,000	70,900	7,600	41,900	0	57,800
52	155,200	82,400	7,800	65,300	80,900	91,740
53	67,800	83,600	7,700	55,100	4,800	77,440
54	47,600	83,800	7,700	40,800	0	57,350
1954-55	26,300	82,900	7,000	29,700	0	41,720
56	144,900	72,500	7,700	77,400	49,300	108,900
Average	56,060	---	6,730	40,390	8,910	56,570

APPENDIX C

SUMMARY OF ESTIMATES OF COSTS

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ESTIMATED COST OF THE MODIFIED RICHVALE PLAN

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Clio Dam and Reservoir	100,000 AF	$ 14,312,000	$ 734,500
Nelson Point Dam and Reservoir	116,000 AF	20,089,000	1,027,000
Nelson Point Tunnel	8' dia.	1,086,000	54,700
Power Plant No. 1 and penstock	12,000 KW	2,462,000	208,200
Minerva Dam and Reservoir		1,063,000	54,100
Minerva-Dogwood Tunnel	9' dia.	13,823,000	697,400
Power Plant No. 2 and penstock	28,000 KW	5,095,000	402,300
Dogwood Dam and Reservoir		3,219,000	164,000
Dogwood-Hartman Bar Tunnel	9.5' dia.	9,546,000	481,600
Power Plant No. 3 and penstock	28,000 KW	5,122,000	403,800
Hartman Bar Dam and Reservoir		1,328,000	67,700
Hartman Bar-Milsap Tunnel	10.25' dia.	13,409,000	676,500
Power Plant No. 4 and penstock	40,000 KW	6,963,000	531,500
Bald Rock Dam and Reservoir		2,747,000	140,000
Bald Rock Tunnel	10.25' dia.	4,992,000	251,900
Power Plant No. 5 and penstock	42,000 KW	6,566,000	509,400
Access roads		6,035,000	399,400
Public recreation facilities			136,600
Taxes foregone			1,269,000
TOTALS		$117,853,000	$8,209,600

ESTIMATED COST OF CLIO-NELSON POINT-SWAYNE PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Clio Dam and Reservoir	100,000 AF	$ 14,314,000	$ 734,600
Nelson Point Dam and Reservoir	116,000 AF	20,088,000	1,026,900
Nelson Point Tunnel	8' dia.	1,086,000	54,700
Power Plant No. 1 and penstock	12,000 KW	2,509,000	211,100
Minerva Dam and Reservoir		1,063,000	54,100
Minerva-Dogwood Tunnel	9.0' dia.	13,820,000	697,200
Power Plant No. 2 and penstock	28,000 KW	5,260,000	411,100
Dogwood Dam and Reservoir		3,219,000	164,000
Dogwood-Hartman Tunnel	9.5' dia.	7,591,000	383,000
Power Plant No. 3 and penstock	28,000 KW	5,738,000	441,900
Hartman Bar Dam and Reservoir		3,887,000	198,000
Hartman-Spoon Tunnel	12.45' and 14.25' dia.	15,501,000	782,000
Spoon Diversion		376,000	19,000
Spoon-Swayne Tunnel	13.75' and 16.0' dia.	3,731,000	188,300
Swayne Dam and Reservoir	280,000 AF	28,892,000	1,480,900
Swayne Tunnel	14.33'	5,015,000	253,000
Swayne Power Plant and penstocks	127,500 KW	19,485,000	1,420,500
Access roads		4,499,000	281,500
Public recreation facilities			161,800
Taxes foregone			
TOTALS		$156,074,000	$10,617,600

ESTIMATED COST OF NELSON POINT-MEADOW VALLEY-NORTH FORK PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Nelson Point Dam and Reservoir	116,000 AF	$ 20,089,000	$1,026,900
Nelson Point-Meadow Valley Tunnel	14' dia.	28,350,000	1,430,300
Meadow Valley Dam and Reservoir	900,000 AF	36,753,000	1,913,700
Meadow Valley-North Fork Tunnel	12.25' dia.	31,590,000	1,593,800
North Fork Power Plant and penstocks	118,500 KW	20,255,000	1,449,000
Red Ridge Diversion		135,000	6,800
Red Ridge Tunnel	7' dia.	5,095,000	257,000
Access roads		1,127,000	62,200
Public recreation facilities			182,600
Taxes foregone			1,003,000
TOTALS		$143,374,000	$8,925,700

ESTIMATED COST OF NELSON POINT-MEADOW VALLEY-BALD ROCK PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Nelson Point Dam and Reservoir	116,000 AF	$ 20,089,000	$ 1,026,900
Nelson Point-Meadow Valley Tunnel	14' dia.	28,350,000	1,430,300
Meadow Valley Dam and Reservoir	900,000 AF	36,734,000	1,913,700
Meadow Valley-Hartman Tunnel	11.25' dia.	37,675,000	1,900,800
Meadow Valley Power Plant	85,000 KW	15,691,000	1,118,000
Hartman Bar Dam and Reservoir		1,328,000	67,700
Hartman Bar Tunnel	13.25 15.5' dia.	15,972,000	805,900
Hartman Bar Power Plant and penstocks		8,950,000	672,400
Bald Rock Dam and Reservoir		2,747,000	140,000
Bald Rock Tunnel	16- 18.5' dia.	6,969,000	351,400
Bald Rock Power Plant and penstock	80,000 KW	11,384,000	858,400
Access roads		4,776,000	274,700
Red Ridge Diversion		324,000	16,400
Public recreational facilities			176,000
Taxes foregone			1,861,000
TOTALS		$190,989,000	$12,613,600

ESTIMATED COST OF TURNTABLE-MEADOW VALLEY-SWAYNE PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Turntable Dam and Reservoir	48,000 AF	$ 14,015,000	$ 713,400
Turntable-Meadow Valley Tunnel	14' dia.	33,591,000	1,694,700
Meadow Valley Dam and Reservoir	900,000 AF	36,733,000	1,913,700
Meadow Valley-Hartman Tunnel	12.5' dia.	42,413,000	2,139,600
Hartman Bar Power Plant and penstock	98,000 KW	15,797,000	1,137,100
Hartman Bar Dam and Reservoir		3,887,000	198,000
Hartman-Spoon Tunnel	14.8- 17.2' dia.	19,700,000	993,900
Spoon Diversion		376,000	19,000
Spoon-Swayne Tunnel	14.25' dia.	4,842,000	244,300
Swayne Dam and Reservoir	280,000 AF	28,893,000	1,408,900
Swayne Tunnel	14.33' dia.	5,015,000	253,000
Swayne Power Plant and penstock	175,000 KW	24,148,000	1,773,900
Red Ridge Diversion		324,000	16,400
Access roads		3,739,000	226,000
Public recreation facilities			197,500
Taxes foregone			2,309,600
TOTALS		$233,483,000	$15,237,900

ESTIMATED COST OF SHEEP CAMP PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Sheep Camp Dam and Reservoir	65,000 AF	$4,764,000	$222,000
Intercepting distribution canal		596,000	27,500
Pumping plant		446,000	20,500
Public recreational facilities			36,000
Electrical energy for pumping			39,000
Operation and maintenance			70,000
TOTALS		$5,806,000	$415,000

ESTIMATED COST OF SQUAW QUEEN PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Squaw Queen Dam and Reservoir	100,000 AF	$4,416,000	$235,300
Pipeline and surge tank	5' dia.	2,498,000	151,000
Access road		383,000	19,300
Power plant and penstock	12,000 KW	2,115,000	195,500
Public recreation facilities			58,100
Taxes foregone			101,500
TOTALS		$9,394,000	$760,900

ESTIMATED COST OF GENESEE RECREATION PROJECT

(Based on prices prevailing in 1959)

Item	Size	Cost	
		Capital	Annual
Genesee Dam	9,600 AF	$2,367,000	$121,360
Park and reservoir land		816,000	41,200
Public recreational facilities			147,400
TOTALS		$3,183,000	$309,900

BULLETIN NO. 59-2

INVESTIGATION OF UPPER FEATHER RIVER
BASIN DEVELOPMENT

APPENDIX D

PRELIMINARY EVALUATION OF THE EFFECT OF UPPER FEATHER RIVER BASIN DEVELOPMENT ON FISH AND WILDLIFE

Prepared under the supervision of

DAVID E. PELGEN
Fisheries Biologist IV

by
E. V. DWYER
Fisheries Biologist III

and

ROBERT MACKLIN
Fisheries Management Supervisor

STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME

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STATE OF CALIFORNIA
Department of Fish and Game
722 Capitol Avenue
Sacramento 14

March 31, 1960

Honorable Harvey O. Banks, Director
Department of Water Resources
1120 N Street
Sacramento 14, California

Subject: Preliminary Evaluation of the Effect of Upper Feather River Basin Development on Fish and Wildlife.

Dear Mr. Banks:

I am pleased to transmit herewith a report entitled, "Preliminary Evaluation of the Effect of Upper Feather River Basin Development on Fish and Wildlife." This report was prepared by the Contract Services Section of the Department of Fish and Game as part of the services performed under Contract Number 150345.

The Feather River area is of great importance to fish and wildlife. Its importance will become even greater as the State's population and demand for outdoor recreation increases. Therefore, in addition to providing adequate measures for the protection and maintenance of fish and wildlife resources, I recommend that specific planning for the enhancement of these resources be initiated and incorporated into the Upper Feather River Development.

Department of Fish and Game studies of necessary measures to preserve and enhance fish and wildlife populations of the Upper Feather River Basin are continuing and will be completed late this year. We urge that no decisions or final plans be made for the development of the Middle Fork Feather or Upper Feather River Basin until this study is completed.

Sincerely yours,

W T Shannon

W. T. Shannon
Director

INTRODUCTION

The California Division of Water Resources, in April 1955, published a report entitled, "Report on Upper Feather River Service Area", including as Appendix D a statement by the Department of Fish and Game of the "Ultimate Water Requirements in the Feather River Drainage Basin for Fish and Game".

As a result of the findings of this report and subsequent legislative hearings on the subject, the 1956 session of the California Legislature included as Item 223.1 of the budget, an appropriation to the Department of Water Resources, as successor to the Division of Water Resources, for further studies and reports with recommendations for a construction program. Accordingly, the Department of Water Resources examined the proposed Indian Creek, Frenchman, and Grizzly Valley Projects, and published the results with appropriate recommendations in Bulletin No. 59, entitled "Investigation of Upper Feather River Basin Development, Interim Report on Engineering, Economic, and Financial Feasibility of Initial Units".

The Department of Fish and Game examined the proposed projects with regard to their effect on fisheries and angling resources and prepared a report which was used by the Department of Water Resources in preparation of Bulletin No. 59.

The Department of Water Resources conducted further studies on the possible Squaw Queen Reservoir on Last Chance Creek and the possible Sheep Camp Reservoir on Craycroft Creek.

In recent years, several agencies have taken steps toward possible water development on the Middle Fork Feather River. The Department of Water Resources has examined the proposals and other combinations of possible water development.

The Department of Fish and Game was asked to estimate the present, future, and ultimate use of the fish and game resources of the several project areas, and to estimate the effect of the projects on fish and game resources.

The population of California during the last 30 years has grown at a rate about twice that of the rest of the United States. This rapid growth has strained all of the resources of the State, especially those supporting outdoor recreation. A prediction of the future population growth in the State was published by the Department of Water Resources in Bulletin No. 78, entitled "Feather River and Delta Diversion Projects--Preliminary Summary Report of Alternative Aqueduct Systems to Serve Southern California". This prediction is shown in Figure 1, and indicates that at the year 2020, the population in California will be about 56,000,000. Another prediction of California's future population growth is shown in a report, "Future Population, Economic and Recreation Development of California's Northeastern Counties", prepared by the firm of Harold F. Wise and Associates and entitled Appendix A of Bulletin No. 58, "Northeastern Counties Investigation". This report predicts that the population of California will increase at a rate about 50 percent more rapidly, and that of the Northeastern Counties, about three times more rapidly than the rest of the United States.

The population will exert greatly increased pressure upon the State's resources, and especially upon those of outdoor recreation. Protection and enhancement of these resources require that planning for their development assume large proportions.

;TIMATED PRESENT AND FUTURE POPULATION OF CALIFORNIA

1958 - 2020

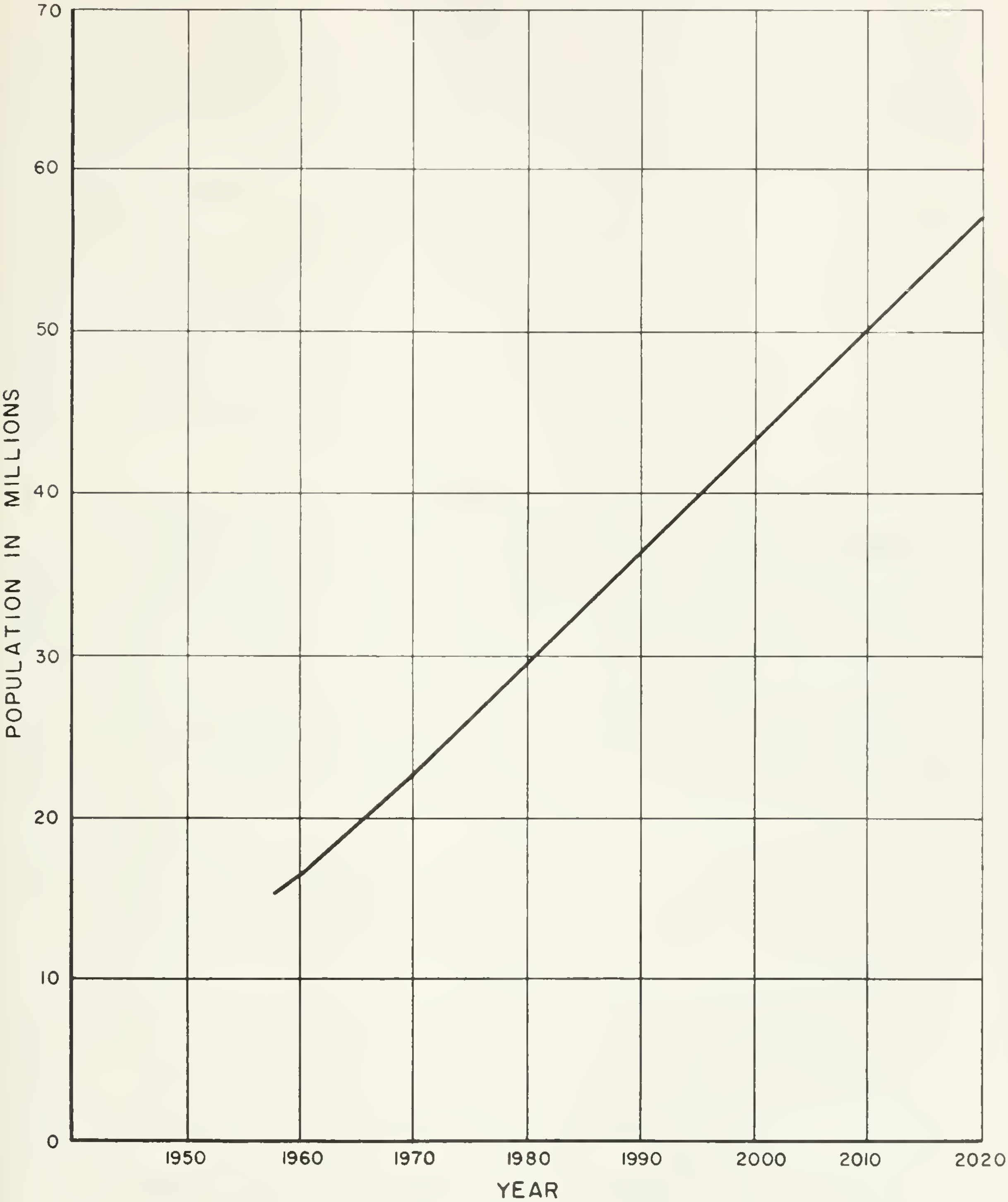


FIGURE I

CHAPTER I. ASSUMPTIONS, CRITERIA AND METHODS

Credence placed in any prediction must depend on stated assumptions and criteria and on the application of these through stated methods. Within the limits established by the adoption of assumptions and criteria, the predictions in this report are reliable.

The concept of the term "ultimate" as used in this work pertains to conditions at the end of a stipulated period in the future when land-use and water-supply development will have reached a maximum, and be essentially stabilized. This "ultimate" year is taken to be the year 2020.

Assumptions

The present increase in the population of California is assumed to continue at a rate and in a degree described by the curve shown on Figure 1. The population at the year 2020, based upon this projection, will be about 56,000,000. The standard of living will continue to rise during this period because of improved technological, economic and sociological conditions. This rise will be reflected in a continued increase per capita use of outdoor recreational resources; therefore, recreational use will increase at a higher rate than the population increase.

Eventually, all outdoor recreational resources will be used at saturation level, considering population density and the availability of recreation. Conditions supporting their use will be available, including transportation, lodging, access and sanitary facilities. Means will be provided to match angling quality or angling success to the public demand at that time. It is also assumed that there will be no major catastrophy, such as war, earthquake, pestilence, or unforeseen cataclysm during the period included in the prediction.

In the interests of reasonableness and believability, the increase of disposable income, leisure time, mobility, etc., will be disregarded, since they would tend to expand the predictions of recreational demand beyond plausibility. It should be noted, however, that these factors, a part of our technological growth, have comparatively recently increased their rate of increase. Should the world ever again come to a condition resembling "Peace on Earth", the economy will experience a truly fantastic growth of consumer-oriented industry. This growth will include industries supplying recreational facilities, and demanding recreational resources.

Criteria

Experience of the Department of Fish and Game with bodies of water undergoing angling use at the present time affords some criteria for judgment of the saturation level of angling in streams and lakes. As an example, on the West Fork San Gabriel River in Los Angeles County, more than 1,000 anglers per stream mile at one time have been counted.

Present conditions of population, remoteness, accessibility and angling success vary throughout the State, and influence the angling public in accepting various levels of angling saturation on different bodies of water. For instance, anglers near great population centers are willing to continue fishing even though almost in physical contact with other anglers, while in remote areas an angler might move on to another spot if any other angler were in sight. The criteria useful today in deciding on a number describing the acceptable level of angling or other recreational saturation will not apply when predicting future levels of such use. The greatly increased urban development and proportionately reduced outdoor recreational area will inevitably cause a greater tolerance for crowding among the majority of the population. This tolerance will manifest itself in acceptance of higher saturation levels of recreational use than are acceptable at the present time.

Criteria adopted for deciding upon a number representing this ultimate angler-use per mile along the Middle Fork Feather River at any one time included the following concepts:

1. The Department of Fish and Game is conducting a study to determine the flow required to maintain the fish population of the Middle Fork Feather River. While not yet completed, indications are that the flow recommendations will be between 125 and 175 second-feet. For the purposes of this study it is assumed that flows within this range will create the most suitable condition for maintenance of the fishery below Nelson Point.

2. Anglers will be willing to fish in groups as large as three in pool areas of the stream. These groups need not be out of sight of each other.

3. Anglers will be willing to fish in groups of two in riffle and run areas of the stream. These groups need not be out of sight of each other.

4. Anglers will not fish in chutes or falls.

5. The canyon stretch of the stream is assumed to comprise 50 percent riffle and run, 30 percent pool and 20 percent unfishable water, such as chutes, falls, or totally inaccessible areas. Pools are here defined as those sections of stream in which the depth is at least one fifteenth of the width and there is a marked decrease in flow velocity.

6. The average length of the angling season will be 180 days.

7. The reaches of the Middle Fork Canyon, which are highly inaccessible now, will remain relatively inaccessible in the future. Roads necessary for proposed construction will be the only access available to motor vehicles in the immediate future and no roads will follow the river nor the reservoirs in the canyon.

8. A minimum system of trails, foot bridges, camps and sanitary facilities will be installed and maintained, consistent with public health and safety and administrative requirements. Pressure of public use will govern the staging of these installations. Such a plan has been adopted by the Plumas County Planning Commission and Board of Supervisors.

9. Narrow, steep-sided, widely fluctuating reservoirs which can store only a small amount of water relative to the total flow, are notoriously poor areas for fish and angling. No foreseeable fisheries management practice can improve the productivity of these reservoirs and inundation of a length of stream by this type of reservoir will reduce the amount of fish and of angling available along that stream by an amount proportionate to their length. Such reservoirs cause indirect harm to trout populations in the entire river by furnishing habitat for Sacramento squawfish which prey upon trout.

Methods

Information about the character of the surrounding area, stream banks, access points and general accessibility, and about the stream itself was gathered by four methods. The first method was to scrutinize maps and aerial photographs. This procedure afforded information about roads, trails and other possible access, and about areas and routes which would probably be inaccessible.

The second method was to interview all persons believed to be authoritative in an aspect of the stream, its recreational use and potential, and its setting. These persons advised on feasibility of running the river by boat, on places, times and methods of angling, and many other subjects relative to this investigation.

The third method was by visiting the stream in various seasons, and at various places. Trips were made by jeep, auto, airplane and on foot carrying a pack. The physical, biological, and scenic features of the of the stream were assessed by this method.

The fourth method was by hydrological study to ascertain the actual flow patterns in the streams. This was done by stream measurements at three stations along the canyon and by correlations computed from recording gages above, in, and below the canyon. This work was performed by personnel of the Department of Water Resources and of Region II of the Department of Fish and Game.

CHAPTER II. PROJECT AREAS AND RELATED FISH AND GAME RESOURCES

The areas and resources which would be affected by possible water development projects will be discussed from the point of view of fish and game resources and the utility of the areas for angling and hunting.

The resources of fish and wildlife, achieve economic significance in the light of availability and use. This aspect of the resource need not take the form of harvest, but may include such values as research, or of contemplation of the forms as an esthetic pursuit.

The requirement of these resources which is of primary concern to this report, however, is that the fish and game species be present and be available for pursuit by sportsmen.

The fisheries with which this report is concerned are primarily rainbow trout and secondarily brown trout, and brown bullhead. Other species exist in the area, including carp, several varities of minnows, suckers and largemouth bass; but these do not support angling of any significance. It is possible that a fishery might develop based on one or more of these species, but it is very improbable that any will become important enough to be considered as a recreational resource.

The game species of primary interest is deer. Bear, waterfowl and upland game are hunted, but are less important.

The fish resources will be discussed by drainage area as affected by project. Because game resources are essentially similar throughout the affected areas, they will be discussed together.

Middle Fork Drainage Area

The part of the Middle Fork drainage area which is of interest to this study lies between the western edge of Sierra Valley and the upper end of the proposed Oroville Reservoir. It is shown on the map appended.

Grizzly and Frenchman Reservoir sites are located in the upper section of the Middle Fork Feather River drainage area. The Frenchman Reservoir site is being developed as a recreation and irrigation reservoir. Grizzly Reservoir has been considered in another report, Department of Water Resources Bulletin No. 59. The benefits vary widely depending on the primary purpose of the project. Since it is doubtful that these proposed reservoirs would be included in any of the proposed plans they have not been considered in this report.

Upper Section

The streams tributary to the Middle Fork Feather River in the western part of Sierra Valley are small. They are largely spring-fed and run across gently sloping meadow lands in well-defined stream beds. They afford good brown and rainbow trout angling to those who know the secrets of success in small streams.

Immediately below the outlet from Sierra Valley, Big Grizzly Creek joins the Middle Fork Feather River. From here to the vicinity of the town of Clio, the river runs in a wide canyon with several very small tributary streams. It drops only gradually and forms many long pools. There is fair access along the banks.

Between the towns of Clio and Sloat, the Middle Fork passes through three rather open valleys in which the stream forms many large pools with a relatively smaller amount of riffle than in the intervening stretches which traverse canyons. The stream in this section drops an average of only about 25 feet per mile. This entire length is easily accessible at present and supports heavy recreational use, including a great deal of angling.

Sheep Camp Reservoir

The site of the possible Sheep Camp Reservoir lies mainly in a broad meadow called Carmen Valley through which runs Craycroft Creek, an intermittent stream. The meadow is surrounded on all sides away from the dam site by an attractive conifer forest with definite edges near the meadow land. The area lies between percipitous mountains to the west and the broad, flat Sierra Valley to the east. The old abandoned road from Calpine to Beckwourth runs past the dam site and access is easy to any part of the reservoir site.

Clio Reservoir Area

The area of the proposed Clio Reservoir includes about 3 stream miles of the Middle Fork Feather River and about 2 stream miles of Sulphur Creek. Both of these are good trout streams and support heavy recreational use.

Gold Lake

This is, at present, a good angling lake. It contains rainbow, brook and brown trout and kokanee salmon. It supports heavy angling pressure and large amounts of other recreational use. Large numbers of trout are planted in the lake annually.

Canyon Section

Below Sloat, the stream runs in a narrow, steep-sided canyon, dropping an average of about 70 feet per mile for about 45 miles to the upper end of the proposed Oroville Reservoir. This rate of fall would indicate that much of the stream should be occupied by riffles, chutes and falls, and this is indeed the case. Bedrock is exposed in many stretches and great boulders are strewn along the canyon bottom showing the power of flood flows in the canyon.

Flows of 32,000 second-feet at Sloat and 62,000 second-feet at Milsap Bar have been measured, and 85,000 second-feet estimated in the Middle Fork at its confluence with the South Fork Feather River.

The canyon is situated at a medium distance from major population centers. This term means about one short day's drive from the San Francisco Bay Area or the Central Valley, or a long day's drive from southern California.

The forest-type ranges from pine-fir-oak association in the canyon bottom at the upper end, to oak-digger pine-poison oak association at the lower end. The most common stereotype in trout anglers' minds is that of pine forests, and the canyon does not conform to this picture.

The most important factor influencing anglers and hunters against choosing the Middle Fork Canyon as their destination is probably the difficulty of access and the roughness of terrain.

There are only two passenger automobile roads to the river between Sloat and Milsap Bar. The upper road, crossing the Middle Fork near Nelson Creek, leads from Quincy to Marysville by way of La Porte. The other road goes south from the Brush Creek Ranger Station to reach the Middle Fork at Milsap Bar where there is a U. S. Forest Service campground. In addition to these roads there are five jeep roads and some foot trails leading to the river. However, once at the river, few trails follow it.

In the upper reaches, the canyon walls are laced with beds of limestone and shale, or slate-like rock, which lie generally across the path of the stream. Near the beds of shale, the soil is composed of clays and small flat rock chips lying in a slippery mass just at the angle of repose. Any disturbance causes slides and travel over them is precarious. The shale beds themselves, exposed to disintegration and decomposition, are extremely difficult to traverse, and enforce detours. During high water, stream-side travel past these beds is impossible and the required detour is up and around.

Added to this picture of rugged terrain, the lack of trails along the canyon prevents any but the most ambitious and best conditioned hiker from following the stream. Anglers, who almost of necessity must carry tackle, food, sleeping bags and other gear, do not use this stretch of the stream in large numbers.

Proposed Dam Locations

The dams proposed for construction in the canyon would be located along the Middle Fork as follows, in miles below Sloat:

Dam	Miles
Turntable	10
Nelson Point	12
Minerva Bar	13
Dogwood	23
Hartman Bar	30
Bald Rock	42

The proposed Red Ridge Diversion Dam would be located at the confluence of the several small streams forming Bear Creek, about 5 miles southwest of the proposed Meadow Valley Reservoir.

The proposed Spoon Diversion Dam would be located on the Little North Fork Feather River about a mile above its confluence with the Middle Fork of the Feather River.

Turntable Reservoir

The area of the proposed Turntable Reservoir includes about 6 miles of the Middle Fork Feather River and about 2 miles of Nelson Creek. Both of these are good trout streams and, in the accessible parts, support heavy recreation use.

Nelson Point Reservoir

The proposed Nelson Point Reservoir is identical to Turntable except that it would include a total of about 9 miles of the Middle Fork Feather River.

Minerva Bar, Dogwood, Hartman Bar and Bald Rock Reservoirs

These reservoirs are all essentially similar in that each would include some length of the Middle Fork Feather River, a good trout stream. The approximate length of stream included in the area of each would be as follows (in feet): Bald Rock Reservoir, 16,500; Hartman Diversion Pond, 4,000; Dogwood Reservoir, 10,000; and Minerva Reservoir, 4,800.

Red Ridge and Spoon Diversion Ponds

The areas of these proposed ponds include negligible lengths of stream and are not important to fisheries resources. The streams are small and steep and do not support large amounts of angling or recreation at present, although good trout populations are present in both streams. Fisheries maintenance flows would be required below the dams.

North Fork Drainage Area

The areas in the North Fork drainage of interest to this study are the proposed Meadow Valley, Swayne and the possible Squaw Queen and Humbug Valley Reservoir sites. Other than Meadow Valley, none of these dams were seriously considered for inclusion in the projects studies. Therefore, no angler use estimates were made.

Meadow Valley Reservoir

The area of the proposed Meadow Valley Reservoir includes about 5 miles of Spanish Creek and several very small streams for their entire fishable length. Spanish Creek supports angling and recreational use. The remainder of the streams in the reservoir area support fishing. The entire Spanish Creek drainage has been treated recently to eradicate a high population of rough fish. It has been restocked with rainbow trout. Angling pressure and success has increased.

Swayne Reservoir

The area of the proposed Swayne Reservoir includes about 5 miles of French Creek and about 5 miles of several small creeks. These are good trout streams, especially for early and late season angling. They support moderate amounts of angling and other recreational use.

Squaw Queen Reservoir

The area of the possible Squaw Queen Reservoir, as described in the report on the Upper Feather River Service Area, 1955, includes about 10 miles of Last Chance Creek and about 3 miles of Squaw Queen Creek. Last Chance Creek in this stretch is a good small stream and supports a good population of trout. This area is relatively inaccessible and the streams are not heavily fished.

Typical annual drawdown in the possible Squaw Queen Reservoir would be about 12 feet, and maximum drawdown during the critical dry period would be about 30 feet. The minimum, or dead pool, would then be about 95 feet deep at the dam, contain about 8,000 acre-feet, and have about 300 surface-acres.

The authorized Dixie Refuge Reservoir on Last Chance Creek would be about 10 miles above this reservoir, and would be operated for stream flow maintenance. With this assured flow, Last Chance Creek should be an excellent trout stream, provided temperatures are suitable.

Humbug Valley Reservoir

The site of the possible Humbug Valley Dam and Reservoir is in a beautiful mountain meadow surrounded by thick forest of conifers and traversed by a very fine trout stream, Yellow Creek. The developed recreation centers at Lake Almanor are only a few miles to the east and people seeking an undeveloped, unspoiled area come to fish and to enjoy this rare combination of remote beauty and easy accessibility. The town of Longville, actually a ranch family headquarters, lies at the head of Humbug Valley looking to the south along the meadow and to the west toward the higher mountains.

Angling is good in the stream and is supported in part by stocking of artificially reared trout.

Game Resources

Deer

The major game in all of the project areas is the deer herds. These deer live in the higher mountainous areas during the warmer seasons and move into lower, less rigorous environment during the winter. In the eastern parts of the Feather River drainage, the deer exhibit generally more distinct and more nearly requisite migratory habit. They travel along traditional paths to their winter ranges and are hampered seriously, sometimes fatally, by obstacles to their migration along these paths. The site of winter range is also part of this traditional pattern, and a migratory herd which loses its winter range might easily be entirely eliminated.

In the lower elevations and in the western parts of this basin, the deer herds exhibit less complete dependence upon certain particular routes and winter ranges. Instead, they move for their winter range into lower elevations, usually at a relatively short distance from their summer living areas.

In all cases, severity of winter, availability of natural browse, and population density exert some effect upon the annual migration.

Another land-use requirement of deer herds is for fawning areas. After the herds leave their winter range and the bucks have started for the higher country, the does seek a meadow area with suitable food, shelter, cover and concealment, near water, where they can produce their fawns.

A herd of approximately 500 deer winters in the site of the proposed Meadow Valley Reservoir, in the area between Slate Creek and Rock Creek. Other deer, from adjacent mountains, depend upon winter range in Meadow Valley to the extent of about 3 square miles.

Other winter range is included in the land which would be inundated by the proposed Clio, Nelson Point, Turntable, Minerva Bar, Dogwood, Hartman Bar, Squaw Queen and Genesee Reservoirs.

Fawning grounds are included in the land to be inundated by the proposed Squaw Queen, Humbug, Clio and Meadow Valley Reservoirs.

<u>Other Wildlife</u>

There are small areas of waterfowl nesting along the streams in every proposed project area. Mallards and blue-winged teal are found here. California mountain quail and bandtailed pigeons are common.

Muskrat and beaver are found along the smaller streams, and otter are found along the canyon section of the Middle Fork.

Black bear are numerous in this region, especially near the lower end of the canyon. Other species of fur bearers and predators are present.

CHAPTER III. EFFECTS OF POSSIBLE WATER PROJECTS ON FISH AND WILDLIFE RESOURCES

The effects of water development projects upon fisheries and wildlife resources are of two categories. The first category includes the effects upon fish, game and other wildlife species, and upon their habitat. The second category includes the effects upon utilization and harvest of these resources and will be discussed in Chapter IV of this report.

There are three major combinations of units considered in this investigation. The first, proposed by the Richvale Irrigation District, would include the Clio, Nelson Point, Minerva Bar, Dogwood, Hartman Bar and Bald Rock Reservoirs and is called the Richvale Project.

The second combination is called, for convenience in this report, the State Proposed Project No. 1 and would include the Turntable, Meadow Valley, Hartman Bar and Bald Rock Reservoirs and the Spoon and Red Ridge diversion ponds, with the diverted water returning to the Middle Fork Feather River.

The third combination is called, for convenience, the State Proposed Project No. 2 and would include the Turntable and Meadow Valley Reservoirs, with the diverted water continuing northward to the North Fork Feather River.

Effects on Fish Populations and Habitat

Clio Reservoir

The proposed Clio Reservoir would be subject to rather large annual fluctuation in water level and would have wide expanses of mud flats during the latter part of each recreation season. During dry years, the fluctuation would be even greater because more water would be released to the stream below.

Wide banks would be exposed during the latter part of every summer recreation season. The temperature of the water in this type of reservoir can be expected to be high in the summer and fall. A temperature problem in the stream below the reservoir may be created by water released provided temperatures are suitable, downstream fisheries benefits are possible. The extent of the benefits would depend on the operation of the reservoir. Since both of these factors are unknown, angler use has not been calculated. The reservoir would not be expected to develop a satisfactory fishery. It would be necessary to stock catchable trout to maintain fishing.

Turntable Reservoir

Nelson Point Reservoir

These two alternative proposed reservoirs would differ primarily in length, due to the different locations of the dams. The Nelson Point dam site is about 3 miles downstream from the Turntable dam site. The water surface elevation would be the same for either.

Comparison with other reservoirs of this type indicate that populations of rainbow and brown trout would develop in the proposed reservoirs. However, they would not support heavy angling pressure without stocking catchable trout.

The steep sides of the reservoir leave few places where recreational and access facilities could be installed, and ultimate recreational use will depend on facilities.

Minerva Bar Reservoir

Dogwood Reservoir

Hartman Bar Reservoir

Bald Rock Reservoir

These proposed reservoirs, essentially similar to each other, can be compared to the existing reservoirs of the Pacific Gas and Electric Company's system on the North Fork Feather River. Angling is poor, even with the support of artificially reared trout. The Department of Fish and Game has observed the fish populations in some of these existing reservoirs and in others of similar nature and has found that trout populations are depressed and rough fish populations are dominant.

Trout will probably not thrive in these proposed reservoirs and angling will probably never be good enough to attract much angler use. The total length of these proposed reservoirs should be subtracted from the length of stream which would in their absence be available for production of fish.

Small forebay reservoirs, such as contemplated in this section, foster populations of Sacramento squawfish, which is considered a rough fish. This species is not only a nuisance to the angler, but is also a detriment to the trout population, since squawfish prey upon trout and compete with them for food. Streams leading into these forebays would be subject to forays by the squawfish which will have grown in the reservoirs.

There are no known means of solving this problem. The Department of Fish and Game is not certain how serious it is, but is attempting to evaluate it. It could mean the loss of the entire Middle Fork Feather River as a trout stream.

A possible means of reducing the effects of these predators upon trout and trout angling would be the installation of barriers above all such reservoirs, and screens at all outlets to the stream. If water from a power plant were to be released into the stream above the next barrier below the plant, means would be required to prevent movement either into the diversion structure, or away from the site of release. Each case would require study to determine what means of predator control would be most feasible and desirable.

Meadow Valley Reservoir

There is no reservoir in California to which this proposed reservoir can be compared exactly. Lake Almanor is at approximately the same elevation, but is relatively shallow. Shasta Lake is of the same magnitude of size, but is at approximately 1,000-foot elevation.

Typical annual drawdown in the proposed Meadow Valley Reservoir would be about 40 feet and maximum drawdown during the critical dry period would be about 130 feet. The minimum or dead pool, would then be about 180 feet deep at the dam, contain about 45,000 acre-feet of water and have about 740 surface acres.

Water conditions in the reservoir would be excellent for fish and would support populations of both warmwater and coldwater varieties of fish. Existing reservoirs with fluctuating water levels and containing soft water have generally produced large fish populations and maintained good angling for a few years after construction and then declined in productivity to a somewhat lower state. A reservoir in Meadow Valley would probably follow this pattern.

Squaw Queen Reservoir

The possible Squaw Queen Reservoir, operated for electric power production, would fluctuate over a wide range annually. Otherwise, the reservoir would offer fairly good habitat for coldwater fishes. It would be of a highly irregular shape and would offer fair to good fish production, decreasing in a few years to poor to fair. The existing stream fishery would be replaced by a reservoir fishery of doubtful value.

Genesee Reservoir - Recreation Project

The possible Genesee Reservoir would be built and operated as a major feature of a Genesee Valley Recreation Area. It would be formed by a dam about 44 feet in height and would cover about 675 acres. The water level would fluctuate only that amount caused by increased flow over the spillway of the dam. The lake would be heavily used by family groups for swimming and boating.

Probably the most beneficial fisheries management scheme for the lake would be to reserve a suitable portion of the shore for angling. The lake would be fairly productive of fish.

Sheep Camp Reservoir

The possible Sheep Camp Reservoir would be constructed and operated primarily for irrigation in Sierra Valley. At normal pool it would cover about 1,630 acres. It would probably be drawn down each year to minimum pool and this annual fluctuation would severely limit the productivity of the reservoir for fish. It will not produce good fishing without stocking the lake with catchable or subcatchable trout. The reservoir would cause no detriment to existing fisheries resources.

Effects on Game Populations and Habitat

The general effect of all these possible water projects on game resources would be to reduce populations of game animals and game birds by reducing the area available to them. The most significant loss would be in the valley and meadow lands which are now used by deer as winter range and fawning area. The two biggest items of this loss would be of deer in Meadow Valley and Mohawk Valley at Clio. The other sites are less important to game species.

Another effect on game would be by the closure of deer migration routes. A small herd of deer near Meadow Valley would be eliminated by the closure of their route from the mountains through Meadow Valley into the western portion of American Valley.

Upland game animals and birds would suffer some minor losses of a nature similar to that of deer.

Migratory waterfowl would be slightly more numerous during their migration periods in the spring and fall because of the additional nesting area on water surfaces. This would not represent a benefit to waterfowl populations because these birds would simply have gone elsewhere to rest in the absence of water in this area.

Fur bearers, including beaver and otter, would suffer a slight loss because they do not live in or very near fluctuating reservoirs. Their habitat is typically along streams, and this would be reduced by inundation of streams by reservoirs.

The major and most immediate consideration relative to fish and game resources in this study is the effect of project construction and operation upon fishing, particularly in the canyon area of the Middle Fork Feather River and in Meadow Valley. Therefore, quantitative estimates are made for only the projects in these areas.

CHAPTER IV. PREDICTION OF ANGLING USE

Economic benefit to be derived from angling use due to a project is the difference between that which would occur <u>without</u> the project, and that which would occur <u>with</u> the project. Therefore, use under both of these conditions must be predicted for a period corresponding to the economic life of the project. It is recognized that the actual and useful life of the project will not be limited to this economic period, but instead will be exceedingly long. For the purposes of this prediction, however, the period between the year 1960 and 2010 is taken as the economic life.

In a project area, or rather in the angling area affected by a project, the amount of angling can be related to the factors of human population size and angling quality plus esthetic attractiveness.

General Effects of Angling Quality and Attractiveness on Angling Use

Angling and esthetic attractiveness are closely related in that water conditions conducive to high esthetic values also tend to produce high angling use. These conditions include stream flow great enough to form beautiful cataracts, rapids and current patterns, but small enough to allow relatively easy wading and stream-side walking.

Angling success, assuming moderate angling skill, depends partly upon the relative number, size and concentration of fish in the stream, and partly upon water conditions. Generally either high- or low-water conditions in streams reduce angling success, while the range of flows which allows good angling success is fairly narrow. In this range, other things being equal, the amount of angling actually available on a given stream depends largely upon the amount of water flowing in that stream. Thus, below the lower end of the range of suitable flows, the amount of angling possibly available is much less than would be available at the optimum flows. Likewise, above the higher end of the range of suitable flows, the amount of available angling tapers off until high-water conditions prevent angling entirely.

Effects of Stream Flow

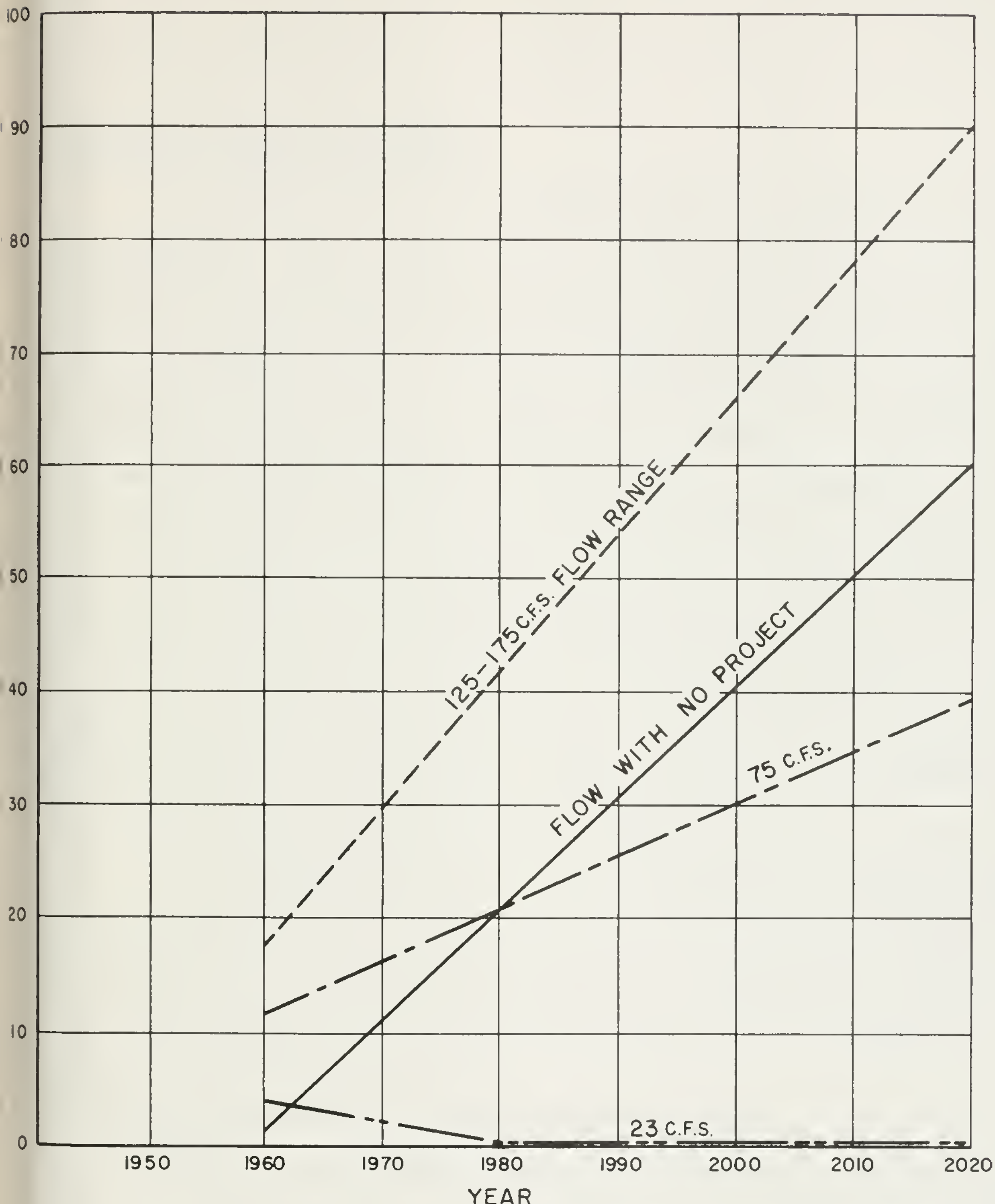
Region II of the Department of Fish and Game is continuing a study to determine the flow required to maintain the fish population of the Middle Fork Feather River. This study is not yet completed, however, indications are that flow recommendations will be between 125 and 175 second-feet. Therefore, in this report, it is assumed that a flow in this range would maintain the fishery below Nelson Point.

It is doubtful that controlled flows of any magnitude would improve fish production significantly over that occurring with existing natural flow conditions. A considerable reduction in fish populations would occur with a constant flow of 75 second-feet. This flow would approximate the existing late summer natural flows. It is believed that the trout fishery eventually would be destroyed with a flow of 23 second-feet (Figure 2).

Effects of Impoundments

Forebay and diversion reservoirs of the size and nature proposed in the Richvale Project and in the State Proposed Project No. 1 are essentially useless in providing desirable fish habitat or angling. High water temperatures combined with suitable rough fish habitat, would result in the replacement of trout by predatory rough fish. Therefore, the length of these reservoirs must be subtracted from the length of stream available in their absence to determine their net effect on the fishery.

PREDICTED PERCENTAGE OF SATURATION OF ANGLING PRESSURE
MIDDLE FORK FEATHER RIVER, 1960 - 2020



NOTE: SEASONAL AVERAGE USE WITH CATCHABLE TROUT.
ANGLING SATURATION: % AVERAGE. SEASONAL USE AT OPTIMUM CONDITIONS

FIGURE 2

Determinations of suitable minimum pools for project reservoirs was beyond the scope of this investigation. It is believed that agreement on adequate minimum pools can be reached by the Department of Fish and Game and the constructing agency.

Effects of Project Development

Difficult access to the canyon stretch of the Middle Fork Feather River presently limits angling use. For the purpose of this report, it is assumed that construction of water projects in the canyon would result in increased means of access. The effect would be to hasten the advent of relatively heavy angling use. Angling use would be greater with the project than without the project, provided adequate flows are maintained, because of the greater number of days that flows would be suitable for fishing.

As the population increases and crowding occurs in other outdoor recreational areas, public demand will result in the improvement of access whether or not the project is built. With no project, the result would be slower development of angling use. There will, however, be comparable use at the ultimate year if increased access is provided.

It is recognized that if plans for reserving the Middle Fork Feather River canyon area as a primitive or natural area are adopted, angler use will be considerably less than would occur with project development. However, even these plans provide for improvement over present means of access.

Effects of Heavy Angling Pressure on Trout Population

Trout are not capable of maintaining large numbers of their kind in the face of heavy angling pressure. Their eggs are large and few, they spawn but once a year and then only very specific environmental conditions. They normally achieve minimum catchable size two or three full years in streams similar to the Middle Fork Feather River.

Considering these factors, it becomes apparent that fish populations will require augmentation from other sources if angling pressure of the magnitude expected is to be supported. It is questionable whether it would be economically possible to manage the fishery with artificially reared trout under present means of financing. However, unless means are developed to increase natural production, artificially propagated trout will play an important part in the management of the fishery.

Effects of Population Growth on Angling Use

Under the assumption stated in Chapter I, that all recreational resources will be used at saturation by or before the assumed ultimate year of 2020, it is reasonable to expect that use will increase at a rate very close to the rate of population increase.

As can be seen in Figure 1, the development curve of population growth approximates a straight line. At the year 2010, the projected population is about 87.5 percent of that at the year 2020. Similarly, the average angling saturation level under 125-175 second-foot flow conditions is shown as 90 percent at the year 2020 and as 77.5 percent at the year 2010 (Figure 2). By using a straight line from the year 1960, to the year 2010, the average angling saturation level for this period can be determined by averaging the figures for 1960 and 2010.

A further assurance of reasonableness or conservatism is given by the disregard of daily turn-over, or the change-about of anglers through the day. A survey of angling use in the Upper Feather River Basin in 1956 showed that approximately 2.5 times as many anglers fished a stretch of stream as were actually present at any one time during the angling day. In the distant future, and at such a remote place as the canyon, anglers might stay for longer periods each day, thus reducing the rate of turnover.

Computation of Ultimate Angling Use

Angling use capacity along a given stretch of stream was computed by multiplying the appropriate number of anglers per mile times the number of miles available. Annual use was computed from this product by multiplying it by the number of days of angling to be available.

Reasonableness requires a factor or less than unity, to take into account inhibiting influences such as bad weather, occasional closures for management purposes, and other unforeseen but probable occurrences. This factor must be arbitrary, and will more closely approach unity as human population increases and recreation resources diminish. In this computation a factor of 0.9 has been adopted for the ultimate year for the stream conditions that would exist with a maintained flow of within the 125-175 second-foot range. Correspondingly, smaller factors have been adopted for smaller flows and for the stream without regulation by any project.

Prediction of angling use on the Middle Fork Feather River below Nelson Point site was based upon the use to be expected under conditions which would occur with assumed optimum flows near Nelson Point. This flow would provide the greatest area of usable fishing water and the greatest amount of beauty or esthetic attractiveness still allowing easy access along the stream and velocities low enough in runs to allow safe wading. At many points along the stream, anglers could wade across the stream on gravel bars. At larger flows angling might be unsafe and at lower flows the area would be less attractive as well as less productive.

The conditions under the 125-175 second-foot flow range would produce or attract or support the maximum amount of angling in the year 2020, and this is shown on Figure 2. On this figure the line representing this flow condition arrives at a level of 90 percent saturation in 2020, because of the reducing factor of 0.9. A straight line is drawn from the year 1960 to the year 2020 between the conditions expected at those two years. It should be noted that the use immediately after construction will be greater under these conditions than with the natural flow because of the publicity and the increased accessibility due to the construction of the projects at the upper end of the stream. A straight line is used following the straight line of the projected population increase during this period. Other lines on Figure 2, depict the use to be expected under conditions with no project, with 75 second-feet, and with 23 second-feet.

The conditions after construction to be caused by flow of 23 second-feet are very poor for angling and for fish; however, the use under those conditions would be greater in the initial period due to the publicity and increased access. In a very few years however, the use would drop off because of poor angling conditions and because of the disappearance of trout. The reduction in trout populations would be due to the unsatisfactory stream conditions for fish.

Angling use with no project would begin at a very low level and would increase in proportion to the population increase in the State at about the same rate as the use would increase with optimum flow conditions. Angling use under conditions with no project would never be quite so high as under the optimum conditions. This difference would be due to the increased number of angling days with the project because of the easy access along the stream during the early part of the summer. With no project the stream would be too large until sometime in June for easy or safe access along and across the stream. Likewise, at the end of the summer, in many years, the flow is too low to be highly attractive or to afford good fishing conditions.

At a controlled flow of 75 second-feet with the project, angling use would be expected to have the initial spurt due to increased access and publicity. Actual increase through the period would be slower than without the project as with higher flows. Conditions for fish would be less desirable than under these other conditions, and the stream would be less attractive for anglers.

Conputations of the ultimate angling use of the Middle Fork Feather River in angler days per year were made for the projects to be compared; namely, the Richvale Proposal and the two state Proposed Projects. The factors and ultimate angler days under project conditions by the several projects are shown in Work Sheets 1, 2 and 3. These sheets are appended to the report. Work sheet 3 also includes the conputations for conditions with no project. These sheets indicate the effects of the projects on the stream assuming a 125-175 second-foot range of flows and 100 percent angler saturation.

The ultimate year (2020) seasonal angling use in angler days at different flows is shown in Table 1. The percentages of saturation developed in Figure 2 were used in computing the angler days per year.

Table 2, shows the average use per year for the period 1960-2010, by project at different flows, and with no project. The use under conditions <u>with</u> the project, minus use <u>without</u> the project, is the use creditable to or lost because of the project.

<u>Effects of Meadow Valley Reservoir</u>

The fishing resource to become available at the Meadow Valley Reservoir would be large enough to be of great significance in the recreation attractiveness of Plumas County. About the third year after the reservoir filled, a fish population would become available which would support a large amount of fishing.

During the initial period for perhaps 10 years after construction, the capacity of this reservoir to support angling will be relatively untouched, and the only limits on fishing will be other factors, such as lack of adequate facilities and distance from population centers.

Average annual angling use during the initial years is predicted to be about 25,000 angler days; and at the year 2050, to be about 160,000 angler days. Average annual angling use for the 50-year economic life is predicted to be about 90,000 angler days. This amount of recreational fishing is credited to the State proposed projects, increasing the total amount of angling afforded. The final comparison of angling to be afforded by the various projects is shown in Table 3.

TABLE 1

PREDICTED ULTIMATE SEASONAL ANGLING USE IN ANGLER DAYS PER YEAR
MIDDLE FORK FEATHER RIVER, BY PROJECT AND WITHOUT PROJECT

Project	125-175 cfs (90% saturation)	75 cfs (40% saturation)	No control (60% saturation)
Richvale Project	391,068	173,808	—
State #1 Project	497,502	221,112	—
State #2 Project	519,534	230,904	—
No Project	—	—	416,068

TABLE 2

PREDICTED AVERAGE ANNUAL ANGLING USE IN ANGLER DAYS, MIDDLE FORK FEATHER RIVER
BY PROJECT AND WITHOUT PROJECT, 50-YEAR PERIOD

Project	125-175 cfs average 47% of ultimate saturation	75 cfs average 24% of ultimate saturation	No control 26% of ultimate saturation	With minus without project	
				Optimum cfs	75 cfs
Richvale Project	204,224	104,284	---	23,061	-76,879
State #1 Project	259,806	132,667	---	78,643	-48,496
State #2 Project	271,312	138,542	---	90,149	-42,621
No Project	---	---	181,163	---	---

TABLE 3

PREDICTED NET AVERAGE ANNUAL ANGLING USE IN ANGLER DAYS, MIDDLE FORK FEATHER RIVER AREA, BY PROJECT 50-YEAR PERIOD

Project	Middle Fork Feather River		Meadow Valley Reservoir	Total 1/	
	125-175 cfs	75 cfs		125-175 cfs	75 cfs
Richvale Project	23,061	-76,879	Not included	23,000	-77,000
State #1 Project	78,643	-48,496	90,000	169,000	42,000
State #2 Project	90,149	-42,621	90,000	180,000	48,000

1/ Rounded to nearest thousand.

Net Effects of Projects on Angling Use

The net effects of the projects on angling use are based on the Middle Fork Feather River from the vicinity of Sloat to the upper end of the proposed Oroville Reservoir. The Middle Fork Feather River above Sloat already supports heavy recreational use. Clio Reservoir is expected to be a marginal reservoir. Depending on operation and temperatures it may increase angler use in the area. Generally, extensive fluctuation in the reservoir or downstream could be expected to decrease the use. Since the operation schedule and water temperatures are not known at this stage of planning no angler use has been calculated for this area. Other upstream developments have been considered in Department of Water Resources Bulletin No. 59.

The predicted 50-year average annual angling use creditable to the Richvale Project would be about 23,000 angler days with a stream maintenance flow in the 125-175 second-foot range. There would be a net loss of about 77,000 annual angler days with a flow of 75 second-feet (Table 4).

The predicted 50-year average annual angling use creditable to State Project Number 1 would be about 169,000 days with the 125-175 second-foot range of flows, and 42,000 man-days at 75 second-feet.

The predicted 50-year average annual angling use creditable to the State Project Number 2 would be about 180,000 angler days with the 125-175 second-foot range of flows, and about 48,000 at a flow of 75 second-feet.

As shown in Table 2, a fisheries maintenance flow of 75 second-feet for either of the state-proposed projects would result in a net loss to the river fishery of from 42,000 to 48,000 annual angler days. It is true that this loss would be more than compensated for by the large number of angler days provided by Meadow Valley Reservoir (Table 3). However, this does not constitute maintenance of the river fishery.

The predicted angling use indicates the project area's importance as a recreation resource. Obviously, this is one of the most important economic benefits to be gained in the area of the water's origin. Therefore, it is of statewide importance that the preservation and enhancement of fish and wildlife of the area be included as a purpose of the proposed project.

TABLE 4

NET CHANGE IN ANNUAL ANGLING USE IN ANGLER DAYS,
MIDDLE FORK FEATHER RIVER AREA,
BY PROJECT 50-YEAR AVERAGE

Project	125-175 cfs	75 cfs
Richvale Irrigation District	23,000	-77,000
State #1 Proposal	169,000	42,000
State #2 Proposal	180,000	48,000

Summary

The California Department of Water Resources under Legislative authority contained in the Appropriation Act of 1956 studied the possible water development of the Middle Fork Feather River as contemplated by several agencies and as conceived by the engineers of the department. The Department of Fish and Game was asked to estimate present, future and ultimate use of the fish and game resources of the several project areas and to estimate the effect of the projects on fish and game resources. Accordingly, the Department of Fish and Game studied the existing fisheries resources, the physical environment of the several project areas and the type and amount of use of these resources in the project areas and along the stream of the Middle Fork Feather River.

In reporting on the results of this survey, certain assumptions and criteria were adopted. The central assumption was that the population of California at the year 2020 would be about 56,000,000. It is also assumed that there will be no major catastrophy and that the standard of living will increase as it has in the past.

Water development projects proposed for the Middle Fork Feather River would alter an excellent trout habitat substantially. Certain conditions would need to be met to maintain the present fishery. These conditions would include reservation of reasonable minimum pool storage in all reservoirs and maintenance of adequate stream flows below all dams.

In order to assist the engineers in their analysis of the various proposals, the conditions under various project operation schedules were also examined. These conditions involved stream flows at three levels in the Middle Fork Feather River; namely 23 second-feet, 75 second-feet and 125-175 second-feet.

The major area of concern in this study was the canyon section of the Middle Fork Feather River, which is largely inaccessible now and which will probably remain relatively so during the 50-year period of analysis. In order to estimate the probable angling use of this section, certain criteria were adopted including flows of 125 to 175 second-feet in the stream in the vicinity of Nelson Point, a distribution of anglers appropriate to the stream flow and size of stream at various places and an average angling season length of 180 days.

The historic stream conditions and present use were examined for this section to furnish bases for estimates of future conditions and use.

All assumptions and conclusions in this report are based on the presence and importance of the fishery which is primarily for rainbow trout and secondarily for brown trout and brown bullhead.

The game species of primary interest in this area are deer, with bear, waterfowl and upland game species of less importance.

The upper reaches of the Middle Fork Feather River runs through Sierra Valley and Mohawk Valley down to the vicinity of Sloat from which the stream goes into the canyon and becomes relatively inaccessible. In the upper reaches use is heavy and angling is maintained partially by planting of catchable trout.

Dams suggested for construction in the canyon would be located along the Middle Fork as follows, in miles below Sloat: Turntable, 10; Nelson Point, 12; and Minerva Bar, 13; Dogwood, 23; Hartman Bar, 30; Bald Rock, 42. Clio Dam would be upstream from Sloat. Two small diversion dams would be located on tributary streams to the north of the Middle Fork itself. A large storage reservoir would be constructed in Meadow Valley about 6 miles west of the town of Quincy. Swayne Reservoir would be constructed on French Creek between the Middle Fork and North Fork. Several other dams and reservoirs were studied, but are not included in the analysis of the major proposals.

In this report, the major proposals are the Richvale Irrigation District Proposal which includes Clio, Nelson Point, Minerva Bar, Dogwood, Hartman Bar and Bald Rock Reservoirs. The State Proposed Project No. 1, includes the Turntable, Meadow Valley, Hartman Bar and Bald Rock Reservoirs and the Spoon and Red Ridge Diversion ponds. The water would be diverted back to the Middle Fork Feather River. The State Proposed Project No. 2, would include the Turntable and Meadow Valley Reservoirs with the diverted water continuing northward to the North Fork Feather River.

Clio Reservoir would be a broad, shallow reservoir fluctuating severely to a small minimum pool. It would not be expected to develop a satisfactory fishery.

Turntable Reservoir and Nelson Point Reservoir are two alternative reservoirs, very similar in character and differing primarily in length. They would be deep and have steep sides and would support moderate populations of trout. Heavy angling pressure would suppress trout populations below good fishing levels.

Minerva Bar, Dogwood, Hartman Bar and Bald Rock Reservoirs would be rather small and would be comparable to the existing reservoirs of the Pacific Gas and Electric Company system on the North Fork Feather River. Angling would be poor, even with the support of artificially reared trout. Stream flow maintenance releases would be required from each.

Meadow Valley Reservoir would be a large, deep reservoir somewhat between cold water and warmwater types. It would not fluctuate severely and would support both trout and warmwater fishes. Angling use during the period of analysis would be large.

The general effect of the small reservoirs would be to reduce available angling and the effect of Meadow Valley Reservoir would be to increase angling.

The effects on game would be harmful, but of relatively small importance. Reservoirs at the higher elevations would inundate deer fawning areas and all would inundate some winter range. Meadow Valley Reservoir would inundate a deer migrating route.

The prediction of angling use is made for conditions with project and for conditions without project. The difference is considered to be the effect on the resources. Necessarily included in the effects will be the result of construction roads which will bring more recreation seekers, anglers, and hunters to the project areas.

Angling use in this survey was computed by multiplying the appropriate number of anglers per mile, times the number of miles available, times the number of days of angling to be available in the season. A use development curve was drawn toward the ultimate day and average angling use was computed from this. A reduction factor to take into account normal annual limitations on use was used to reduce the average annual to the most probable actual figure. A factor of 0.9 has been adopted as this reducing factor with a maintained flow in the 125-175 second-foot range. Correspondingly, smaller factors have been adopted for smaller flows and for the stream without regulation by any project.

Computation of ultimate angling use was made for the projects to be compared, namely the Richvale Proposal and the State Proposed Projects No. 1 and No. 2.

Average angling use at the proposed Meadow Valley Reservoir would be about 25,000 angler days during the initial years, and about 160,000 angler days at the year 2050. Average angling use here would be about 90,000 angler days during the 50-year economic life.

The predicted 50-year average angling use creditable to the Richvale Project would be about 23,000 angler days if the stream were maintained in the range of 125-175 second-feet and a loss of about 77,000 at a flow of 75 second-feet. A trout fishery probably could not be maintained at a flow as low as 23 second-feet.

The predicted 50-year average annual angling use creditable to the State Project No. 1 would be about 169,000 angler days at a stream maintenance flow in the 125-175 second-foot range or about 42,000 at a flow of 75 second-feet. The predicted 50-year average annual angling use creditable to the State Project No. 2 would be about 180,000 angler days with a stream maintenance flow of 125-175 second-feet, and about 48,000 at a flow of 75 second-feet.

Either of the two State Proposals would include the Meadow Valley Reservoir with its large effect upon angling use. Actually there would be a net loss in angling days in the river fishery at flows below the 125-175 second-foot range with any of the proposed projects.

Results of this investigation point out the importance of the water development area for recreation. The outdoor recreation potential of the area is of great importance of people from large population centers. It is an important economic asset to the people of the area. Therefore, it is urged that preservation and enhancement of fish and wildlife be a purpose of any water development project in the area.

Recommendations

The Department of Fish and Game is presently conducting studies to determine necessary protective measures for fish and wildlife. These studies include minimum pools for project reservoirs, downstream fisheries maintenance releases, fish screens and deer protective devices on open conduits and canals. Such necessary protective measures should be incorporated into construction and operation plans before their final adoption by any construction agency.

In planning water development in this area all possible consideration should be given to the enhancement of fish and wildlife.

Public access should be guaranteed at all project reservoirs.

WORK SHEET 1

ULTIMATE ANGLER DAYS PER YEAR ALONG MIDDLE FORK FEATHER RIVER
PROPOSED RICHVALE PROJECT CONDITIONS*

Richvale Project	Length of stream in miles	Length of reservoir in miles	Remaining stream length in miles	Length of riffle and run in miles (50%)	Length of pool in miles (30%)	Length of unfishable stream in miles (20%)	Number of anglers along riffled run at 70 anglers/mile	Number of anglers along pools at 160 anglers/mile	Total anglers per mile	Angler days in ultimate year
Sloat to Minerva dam site (including Nelson Point dam site)	13.2	11.1 1.1	1	.5	.3	.2	35	48	83	14,940
Minerva to Dogwood dam site	9.8	1.4	8.4	4.2	2.5	1.7	294	400	694	124,920
Dogwood to Hartman Bar dam site	7.1	1.8	5.3	2.7	1.6	1.0	189	256	445	80,100
Hartman to Bald Rock dam site	12	2	10	5.0	3.0	2.0	350	480	830	149,400
Bald Rock to Oroville Reservoir	4.4	---	4.4	2.2	1.3	0.9	154	208	362	65,160
TOTALS	46.5	9.4	27.1	14.6	8.7	5.8	1,022	1,392	2,414	434,520

* Stream flow at 125 cfs at Cleghorn Bar: 100 per cent saturation at ultimate day.

WORK SHEET 2

ULTIMATE ANGLER DAYS PER YEAR ALONG MIDDLE FORK FEATHER RIVER
STATE PROPOSED PROJECT NO. 1 CONDITIONS*

State Project No. 1	Length of stream in miles	Length of reservoir in miles	Remaining stream length in miles	Length of riffle and run in miles (50%)	Length of pool in miles (30%)	Length of unfishable stream in miles (20%)	Number of anglers along riffled run at 70 anglers/mile	Number of anglers along pools at 160 anglers/mile	Total anglers per mile	Angler days in ultimate year
Sloat to Turntable dam site	9	8	1	.5	.3	.2	35	48	83	14,940
Turntable to Hartman Bar dam site	20.5	1.5	19	9.5	5.7	3.8	665	912	1,577	283,860
Hartman to Oroville Reservoir	17	---	17	8.5	5.1	3.4	595	816	1,411	253,980
TOTALS	46.5	9.5	37	18.5	11.1	7.4	1,295	1,776	3,071	552,780

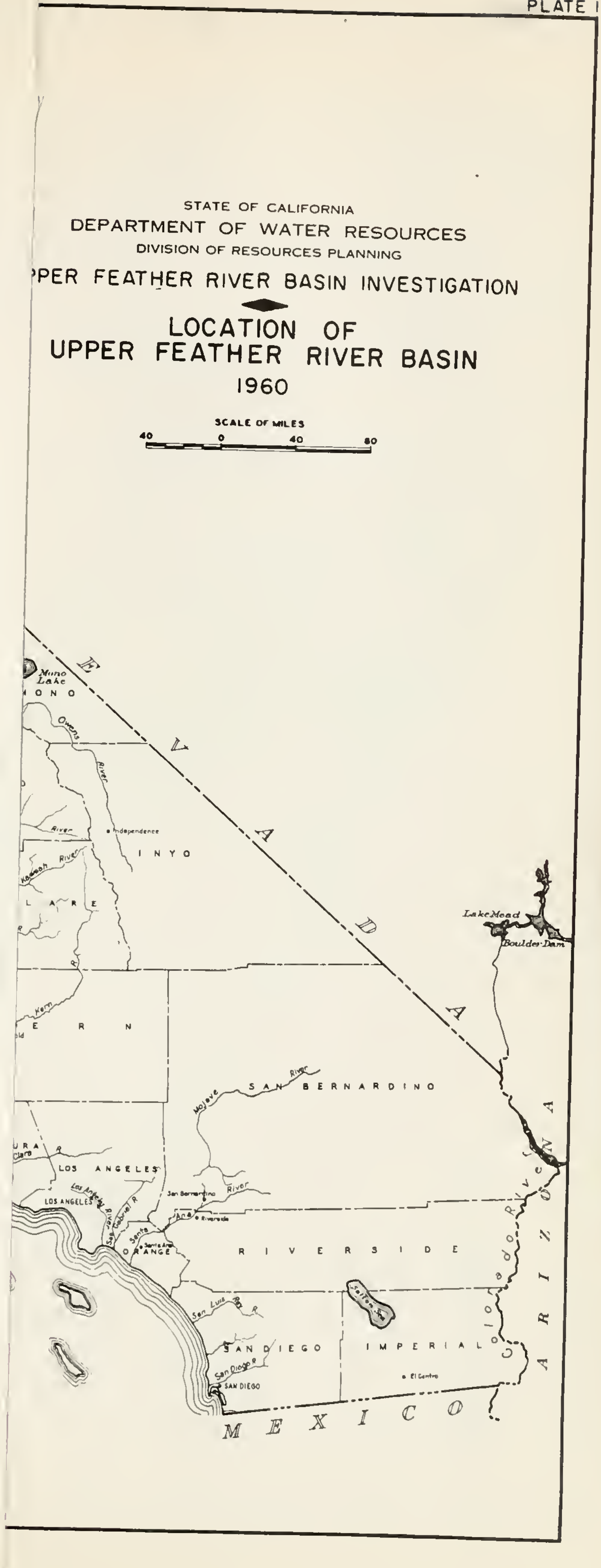
* Stream flow at 125 cfs at Cleghorn Bar: 100 per cent saturation at ultimate day.

WORK SHEET 3

ULTIMATE ANGLER DAYS PER YEAR ALONG MIDDLE FORK FEATHER RIVER
STATE PROPOSED PROJECT NO. 2 CONDITIONS*

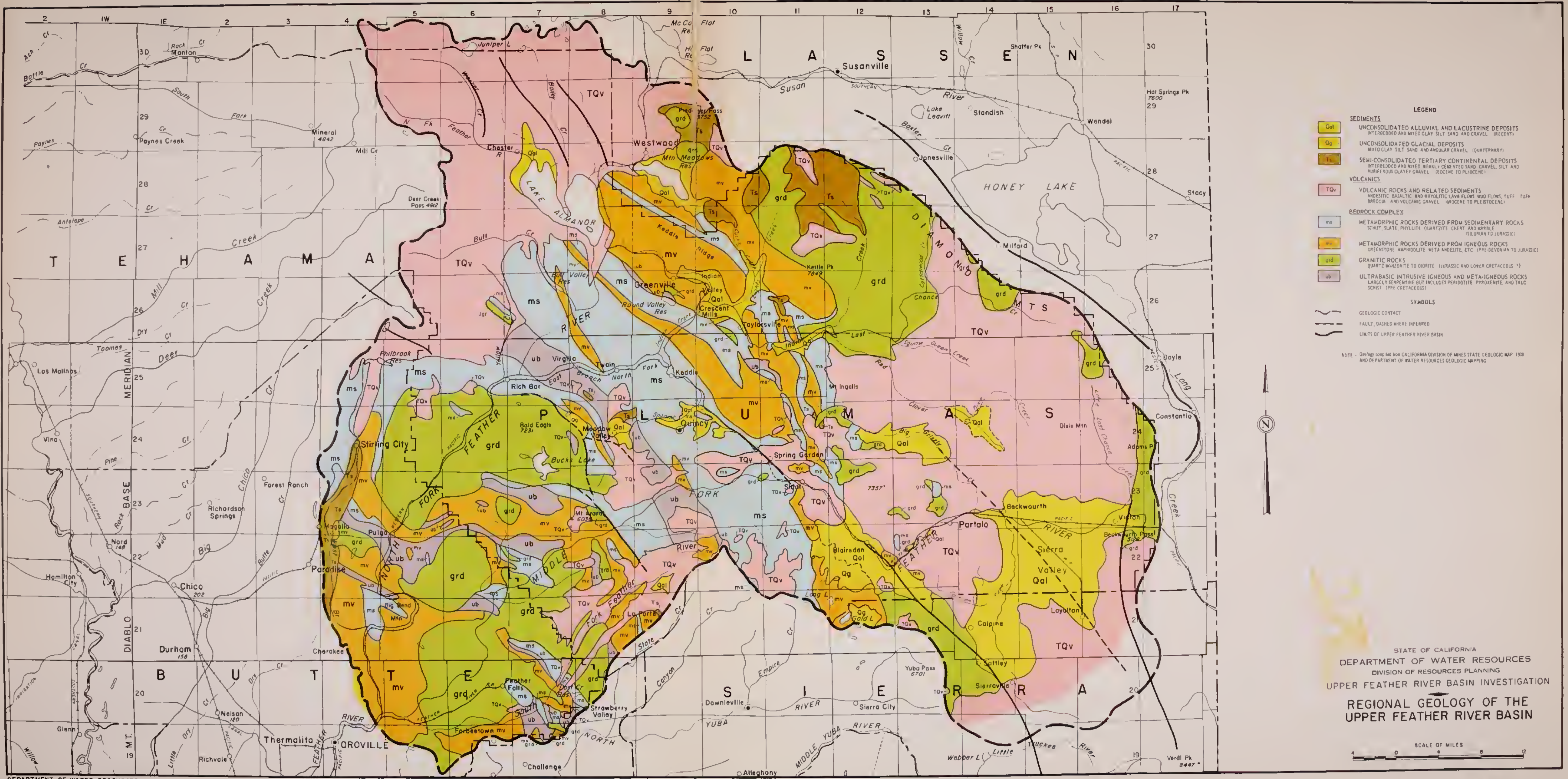
State Project No. 2	Length of stream in miles	Length of reservoir in miles	Remaining stream length in miles	Length of riffle and run in miles (50%)	Length of pool in miles (30%)	Length of unfishable stream in miles (20%)	Numbers of anglers along riffled run at 70 anglers/mile	Number of anglers along pool at 160 anglers/mile	Total anglers per mile	Angler days in ultimate year
Sloat to Turntable dam site	9	8	1	.5	.3	.2	35	48	83	14,940
Turntable to Oroville Reservoir	37.5	-	37.5	18.8	11.3	7.4	1,316	1,808	3,124	562,320
TOTALS	46.5	8	38.5	19.3	11.6	7.6	1,351	1,856	3,207	577,260
No Project	46.5	-	46.5	23.2	14.0	9.2	1,631	2,240*	3,871*	696,780*

* Stream flow 125 cfs at Cleghorn Bar: 100 per cent saturation of ultimate day.

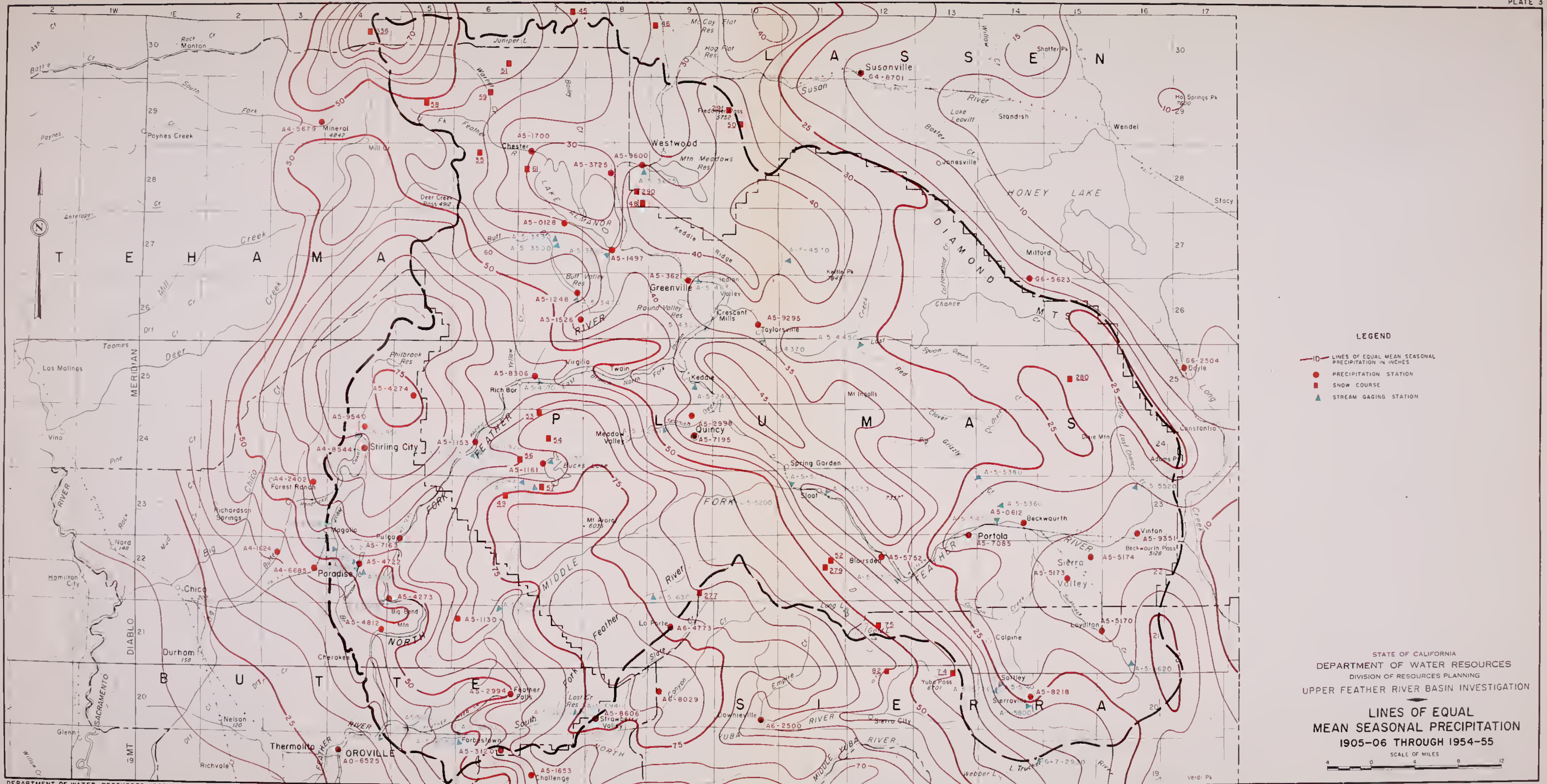

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
PPER FEATHER RIVER BASIN INVESTIGATION
LOCATION OF
UPPER FEATHER RIVER BASIN
1960
SCALE OF MILES
40 0 40 80
N E V A D A
Mono Lake
O N O
Owens River
Independence
I N Y O
Kaweah River
Kern
E R N
Lake Mead
Boulder Dam
Mojave River
S A N B E R N A R D I N O
L O S A N G E L E S
LOS ANGELES
San Gabriel R
San Bernardino
Riverside
Santa Ana
Santa Ana
R A N G E
R I V E R S I D E
Salton Sea
San Luis Rey R
S A N D I E G O
San Diego R
SAN DIEGO
I M P E R I A L
El Centro
Colorado River
A R I Z O N A
M E X I C O


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER FEATHER RIVER BASIN INVESTIGATION
LOCATION OF
UPPER FEATHER RIVER BASIN
1960
SCALE OF MILES
40 0 40 80
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
Goose Lake
Eagle Lake
Honey Lake
Lake Almanor
Lake Tahoe
Mono Lake
Clear Lake
Lake Mead
Boulder Dam
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
MENDOCINO
GLENN
BUTTE
COLUSA
LAKE
SONOMA
YOLO
SACRAMENTO
ALPINE
MONO
INYO
SAN FRANCISCO
ALAMEDA
SANTA CLARA
SAN BENITO
MONTEREY
FRESNO
TULARE
KINGS
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

PLATE 2



DEPARTMENT OF WATER RESOURCES 1960



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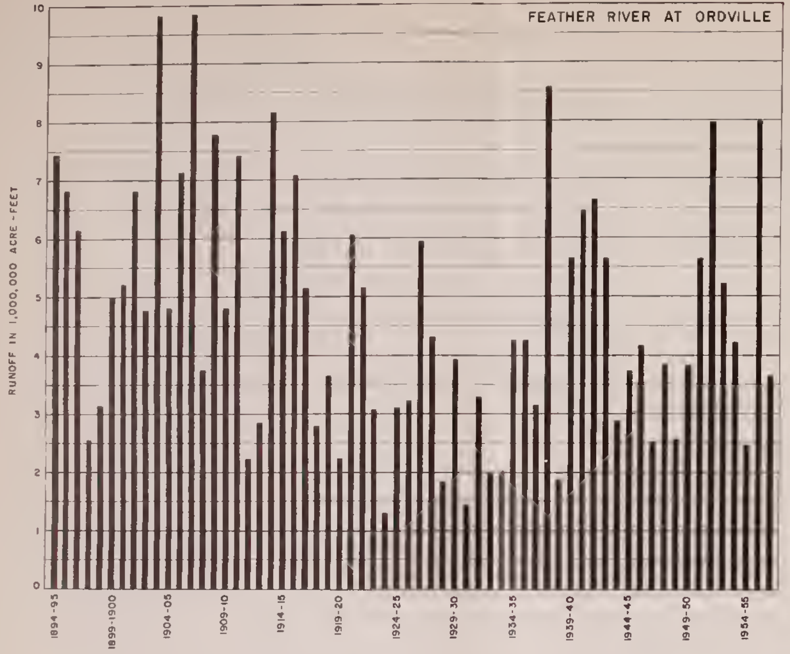
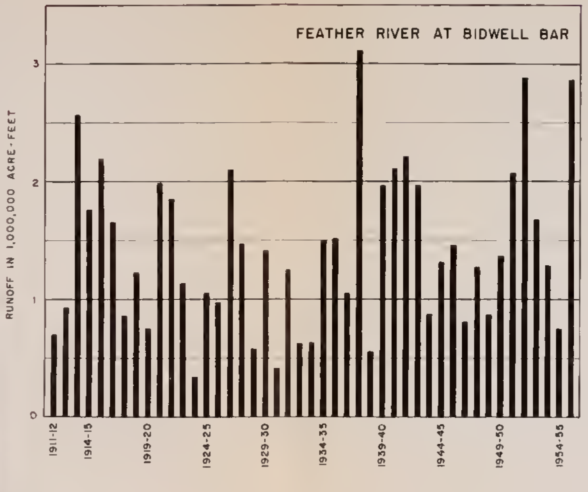
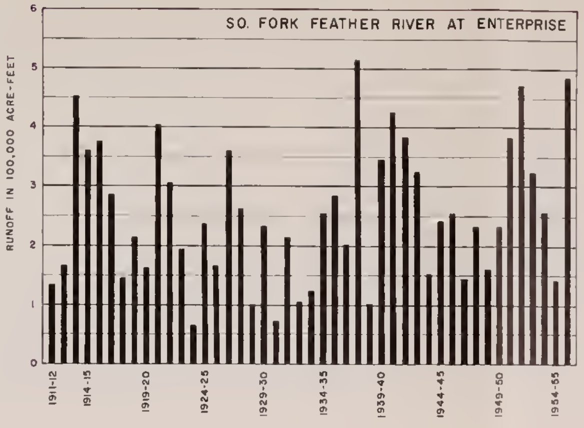
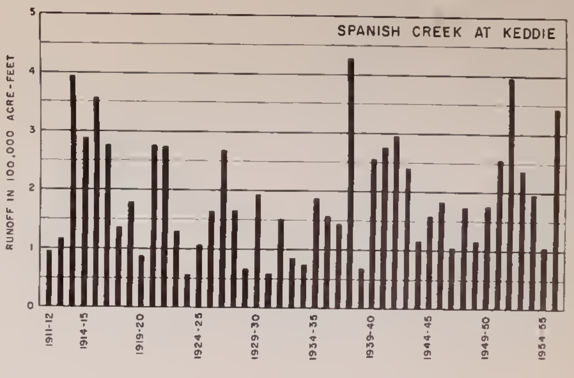
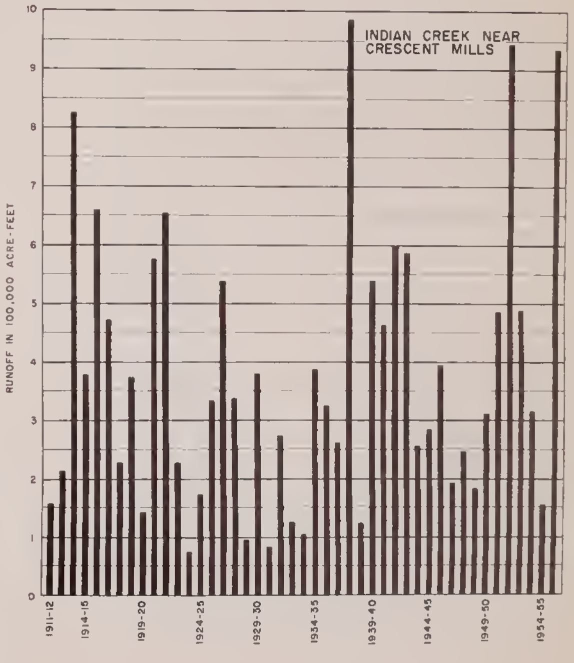
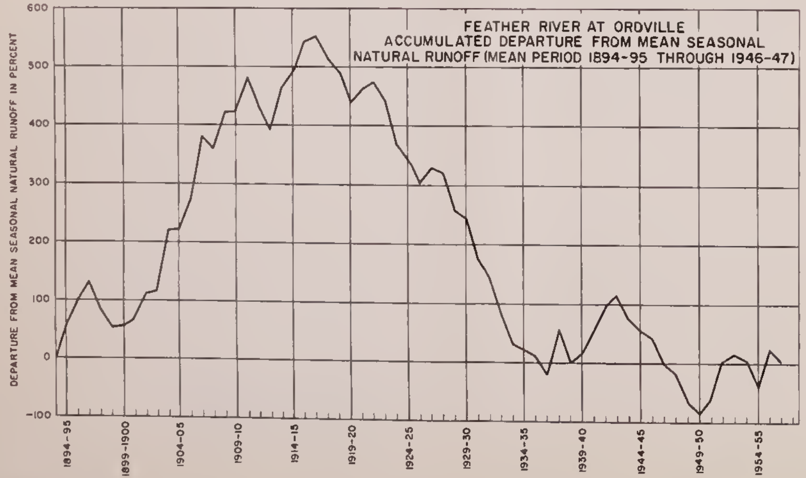


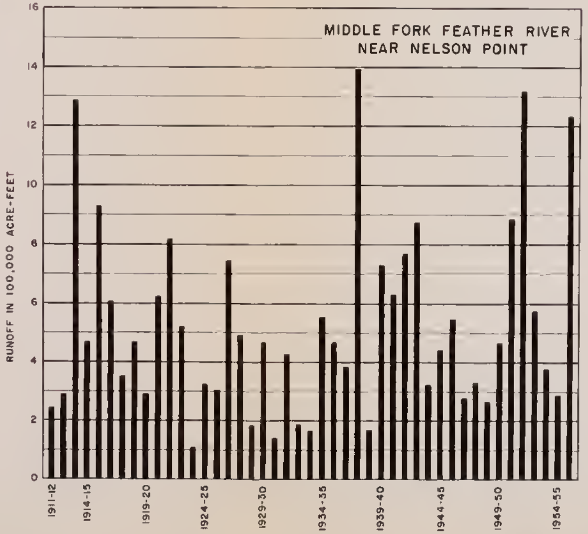


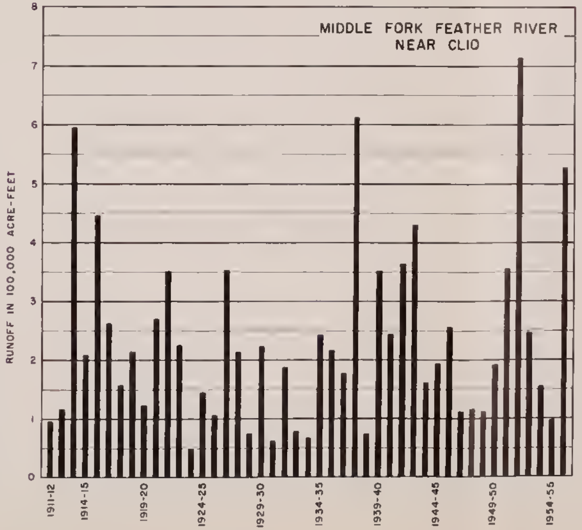






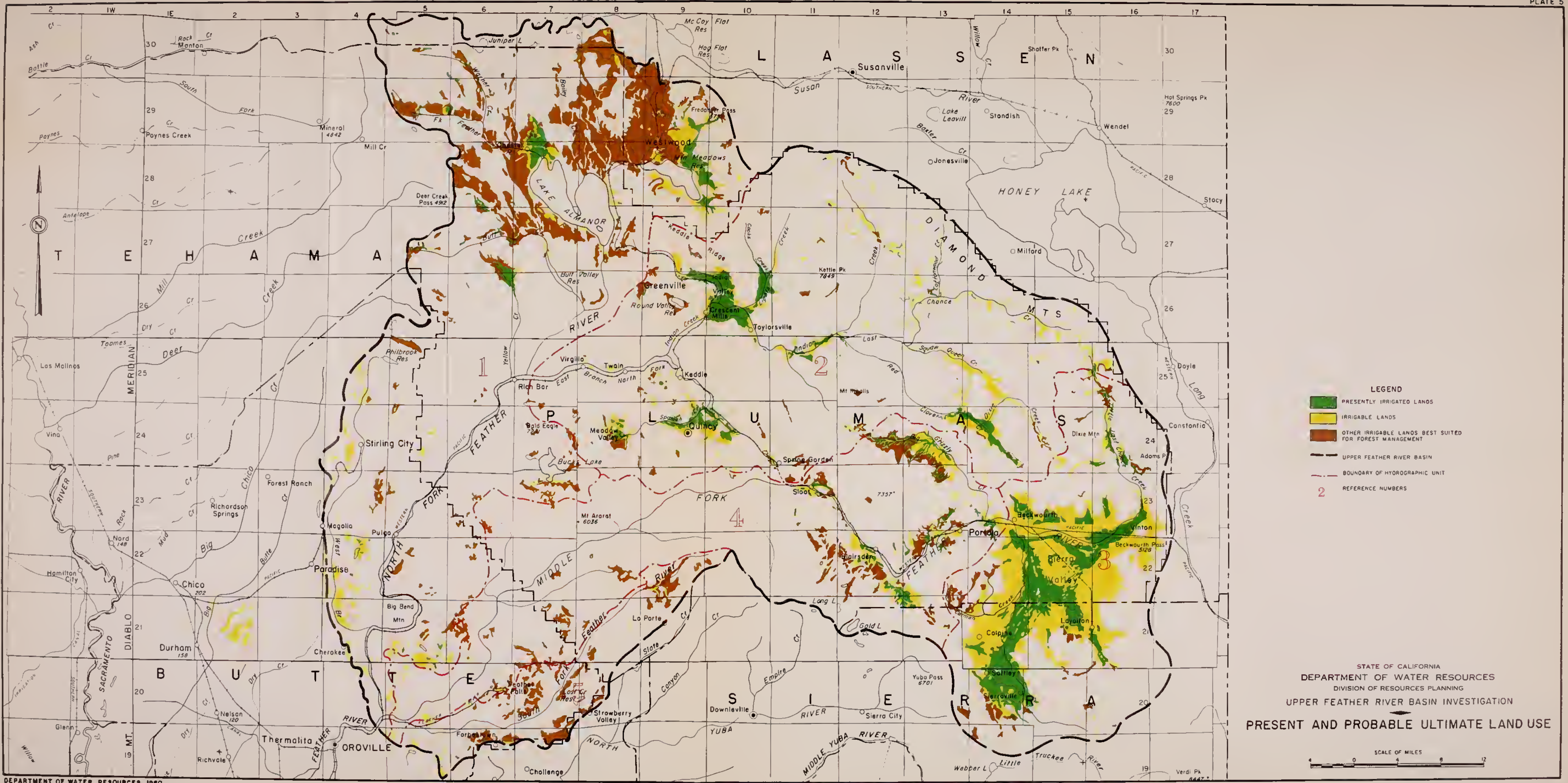






STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER FEATHER RIVER BASIN INVESTIGATION

ESTIMATED NATURAL SEASONAL RUNOFF AT SELECTED STATIONS IN THE UPPER FEATHER RIVER BASIN



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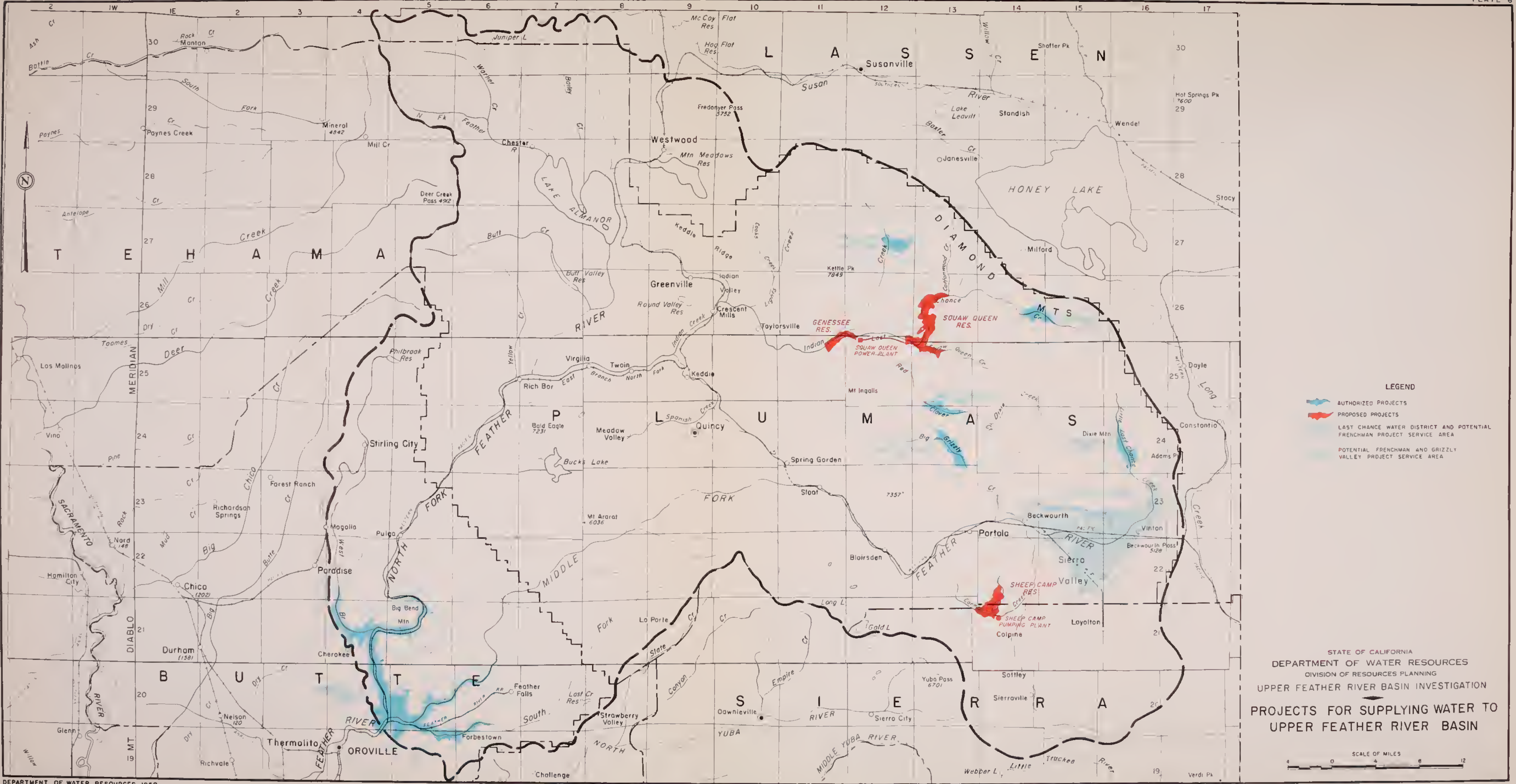

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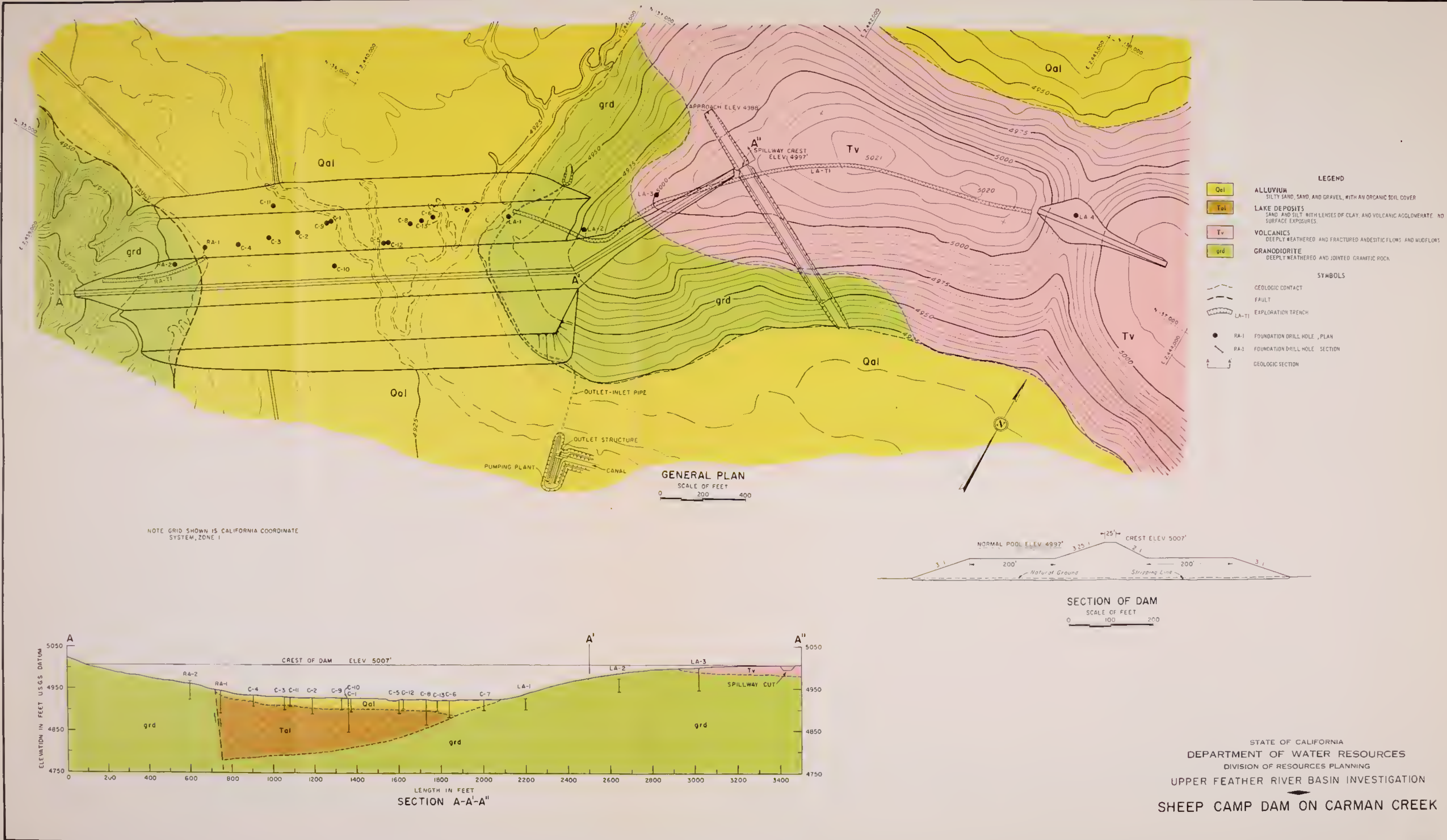
GENERAL PLAN
SCALE OF FEET
0 200 400
Qal
grd
Tv
APPROACH ELEV 4988'
A''
SPILLWAY CREST ELEV 4997'
LA-T1
LA-3
LA-2
LA-1
LA 4
A'
A
RA-1
RA-2
RA-T1
C-1
C-2
C-3
C-4
C-6
C-7
C-8
C-9
C-10
C-11
C-12
C-13
FAULT
OUTLET-INLET PIPE
OUTLET STRUCTURE
PUMPING PLANT
CANAL
NOTE GRID SHOWN IS CALIFORNIA COORDINATE SYSTEM, ZONE I
LEGEND
ALLUVIUM
SILTY SAND, SAND, AND GRAVEL, WITH AN ORGANIC SOIL COVER
LAKE DEPOSITS
SAND AND SILT WITH LENSES OF CLAY, AND VOLCANIC AGGLOMERATE. NO SURFACE EXPOSURES.
VOLCANICS
DEEPLY WEATHERED AND FRACTURED ANDESITIC FLOWS AND MUDFLOWS
GRANODIORITE
DEEPLY WEATHERED AND JOINTED GRANITIC ROCK
SYMBOLS
GEOLOGIC CONTACT
FAULT
EXPLORATION TRENCH
FOUNDATION DRILL HOLE, PLAN
FOUNDATION DRILL HOLE SECTION
GEOLOGIC SECTION
NORMAL POOL ELEV 4997'
25'
CREST ELEV 5007'
200'
Natural Ground
Stripping Line
SECTION OF DAM
SCALE OF FEET
0 100 200
CREST OF DAM ELEV 5007'
SPILLWAY CUT
Tal
ELEVATION IN FEET USGS DATUM
LENGTH IN FEET
SECTION A-A'-A''
STATE OF CALIFORNIA
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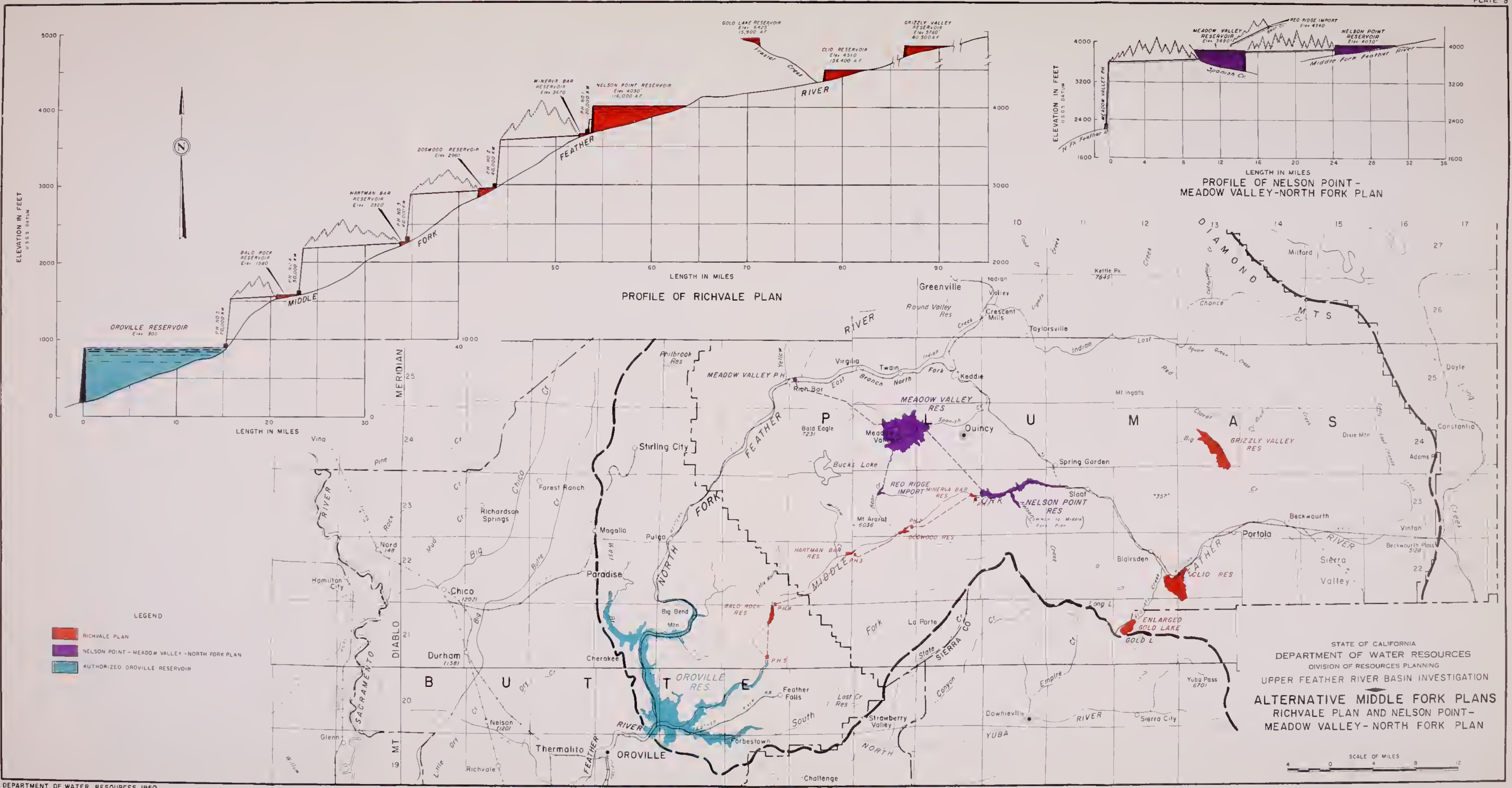
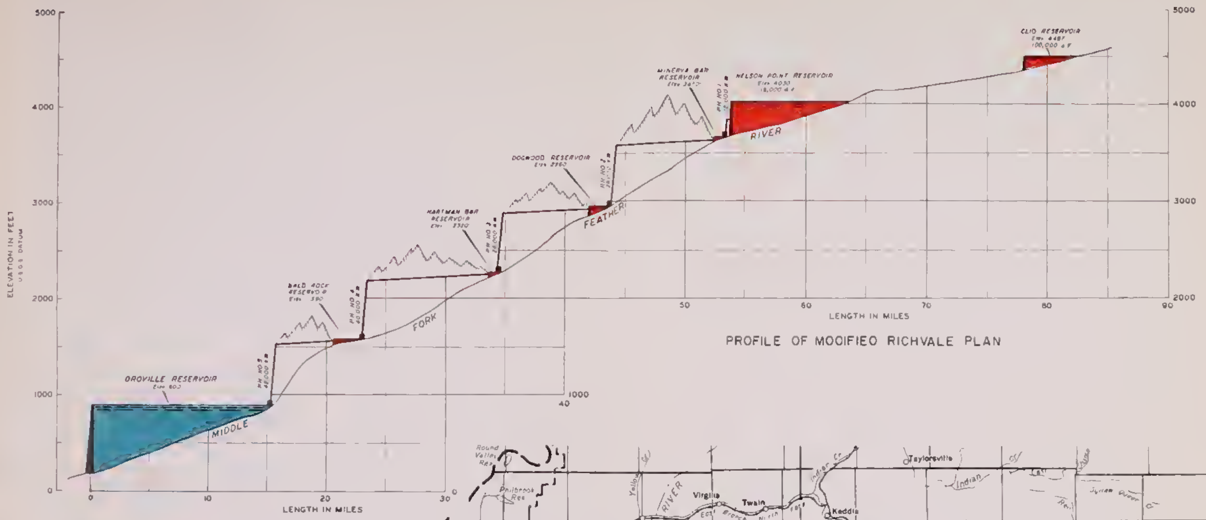
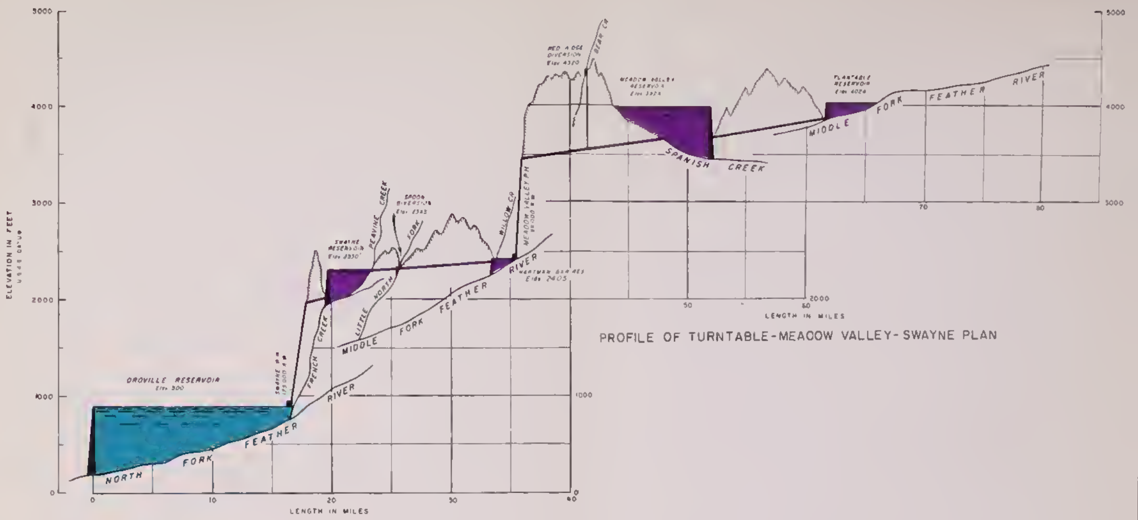
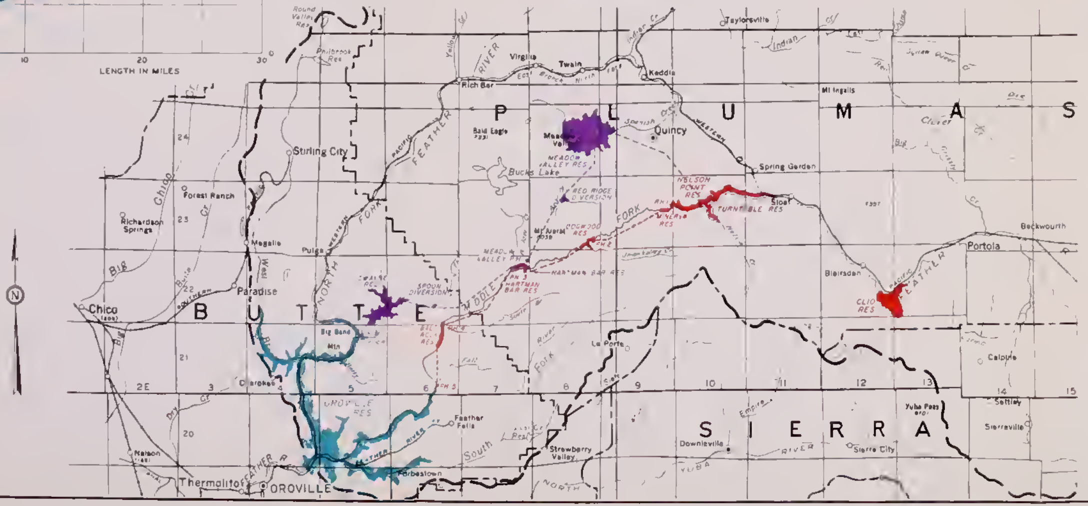
DIVISION OF RESOURCES PLANNING
UPPER FEATHER RIVER BASIN INVESTIGATION
SHEEP CAMP DAM ON CARMAN CREEK


PROFILE OF RICHVALE PLAN
LENGTH IN MILES
ELEVATION IN FEET
USGS DATUM
OROVILLE RESERVOIR
BALD ROCK RESERVOIR
HARTMAN BAR RESERVOIR
DOGWOOD RESERVOIR
MINERVA BAR RESERVOIR
NELSON POINT RESERVOIR
CLIO RESERVOIR
GOLD LAKE RESERVOIR
GRIZZLY VALLEY RESERVOIR
MIDDLE FORK FEATHER RIVER
PROFILE OF NELSON POINT - MEADOW VALLEY - NORTH FORK PLAN
MEADOW VALLEY RESERVOIR
NELSON POINT RESERVOIR
REO RIDGE IMPORT
Middle Fork Feather River
Spanish Cr
LEGEND
RICHVALE PLAN
NELSON POINT - MEADOW VALLEY - NORTH FORK PLAN
AUTHORIZED OROVILLE RESERVOIR
BUTTE
PLUMAS
SIERRA CO
DIAMOND MTS
MEADOW VALLEY RES
NELSON POINT RES
GRIZZLY VALLEY RES
CLIO RES
ENLARGED GOLD LAKE
OROVILLE RES
BALD ROCK RES
HARTMAN BAR RES
DOGWOOD RES
MINERVA BAR RES
MEADOW VALLEY PH
Oroville
Chico
Paradise
Quincy
Greenville
Portola
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER FEATHER RIVER BASIN INVESTIGATION
ALTERNATIVE MIDDLE FORK PLANS
RICHVALE PLAN AND NELSON POINT-
MEADOW VALLEY - NORTH FORK PLAN
SCALE OF MILES







LEGEND

- MODIFIED RICHVALE PLAN
- TURNTABLE MEADOW VALLEY-SWAYNE PLAN
- AUTHORIZED OROVILLE RESERVOIR

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DEPARTMENT OF WATER RESOURCES
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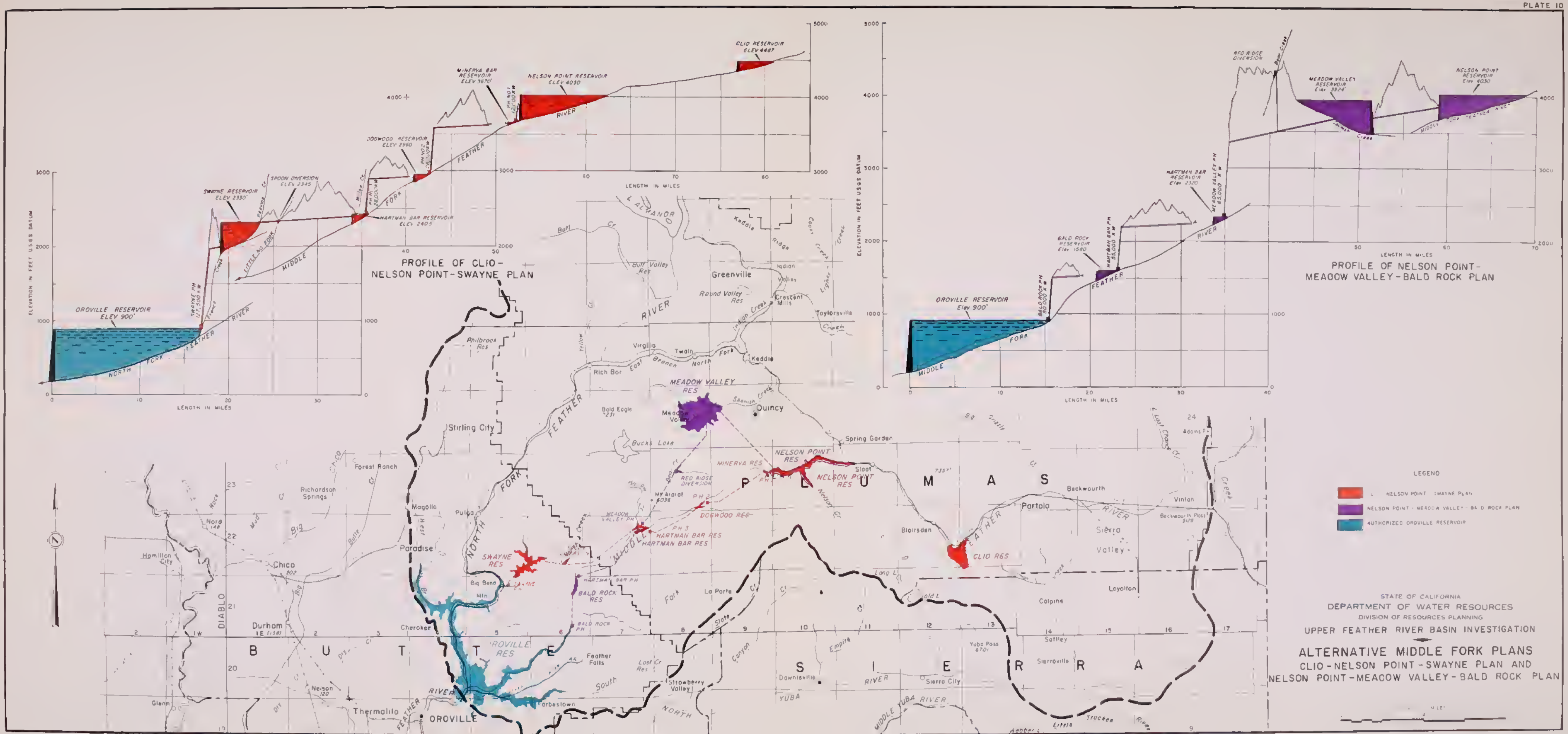
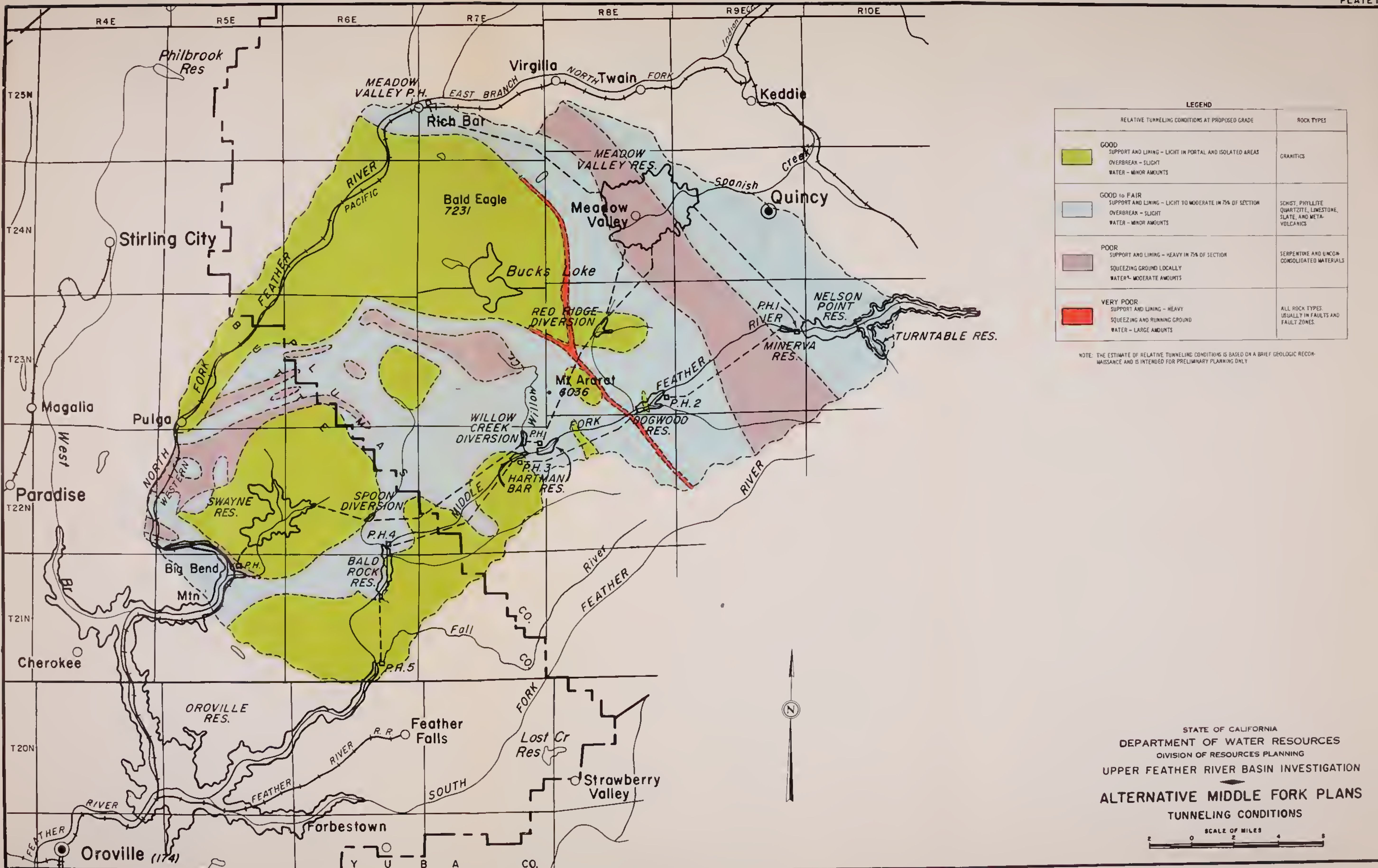
UPPER FEATHER RIVER BASIN INVESTIGATION

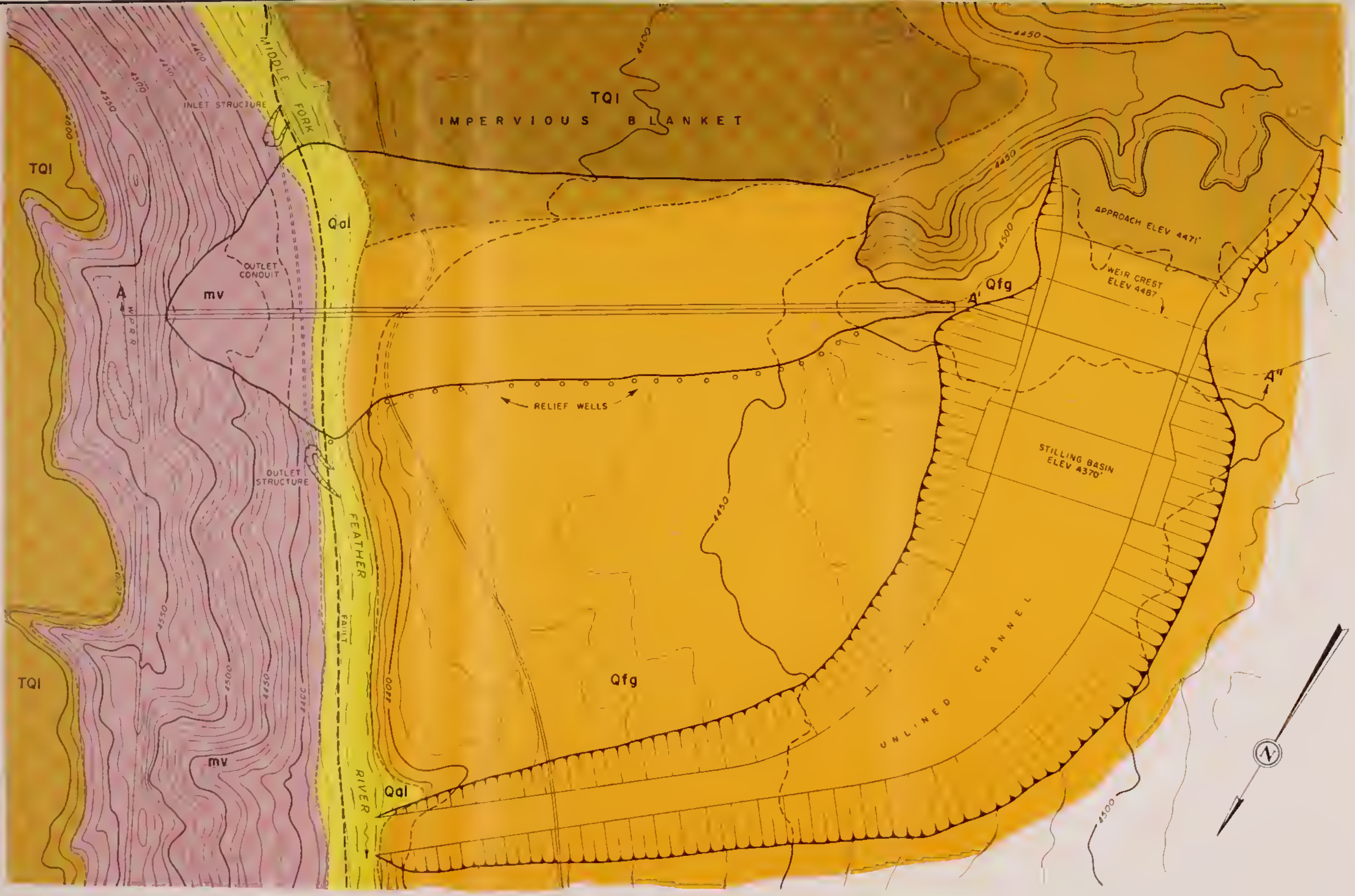
ALTERNATIVE MIDDLE FORK PLANS
MODIFIED RICHVALE PLAN AND TURNTABLE MEADOW VALLEY-SWAYNE PLAN

SCALE OF MILES
4 0 4 8 12


PROFILE OF CLIO-
NELSON POINT-SWAYNE PLAN
OROVILLE RESERVOIR
ELEV 900'
SWAYNE RESERVOIR
ELEV 2330'
SPOON DIVERSION
ELEV 2345
HARTMAN BAR RESERVOIR
ELEV 2405
DOGWOOD RESERVOIR
ELEV 2960
MINERVA BAR
RESERVOIR
ELEV 3670'
NELSON POINT RESERVOIR
ELEV 4030
CLIO RESERVOIR
ELEV 4487
ELEVATION IN FEET USGS DATUM
LENGTH IN MILES
NORTH FORK FEATHER RIVER
MIDDLE FORK FEATHER RIVER
PROFILE OF NELSON POINT-
MEADOW VALLEY-BALD ROCK PLAN
OROVILLE RESERVOIR
Elev 900'
BALD ROCK
RESERVOIR
Elev 1560
HARTMAN BAR
RESERVOIR
Elev 2320
MEADOW VALLEY
RESERVOIR
Elev 3924'
RED RIDGE
DIVERSION
NELSON POINT
RESERVOIR
Elev 4030
MIDDLE FORK FEATHER RIVER
LEGEND
NELSON POINT - SWAYNE PLAN
NELSON POINT - MEADOW VALLEY - BALD ROCK PLAN
AUTHORIZED OROVILLE RESERVOIR
MEADOW VALLEY RES
NELSON POINT RES
MINERVA RES
RED RIDGE DIVERSION
DOGWOOD RES
HARTMAN BAR RES
SWAYNE RES
BALD ROCK RES
OROVILLE RES
CLIO RES
BUTTE
PLUMAS
SIERRA
Quincy
Greenville
Oroville
Paradise
Chico
Portola
Sierra Valley
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER FEATHER RIVER BASIN INVESTIGATION
ALTERNATIVE MIDDLE FORK PLANS
CLIO-NELSON POINT-SWAYNE PLAN AND
NELSON POINT-MEADOW VALLEY-BALD ROCK PLAN



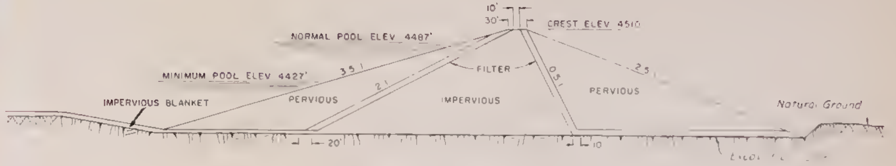
DEPARTMENT OF WATER RESOURCES 1960



GENERAL PLAN

SCALE OF FEET

200 0 200



MAXIMUM SECTION

SCALE OF FEET

0 100

LEGEND

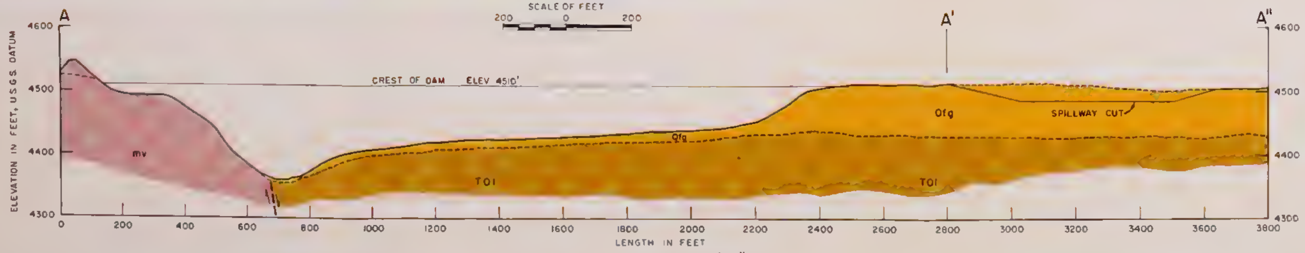
Qal	ALLUVIUM STREAM CHANNEL DEPOSITS-SILT, SAND, AND GRAVEL
Qfg	FLUVIOGLACIAL DEPOSITS GLACIAL OUTWASH-POORLY GRADED AND UNCONSOLIDATED SAND GRAVEL, AND BOULDERS
TQl	LAKE SEDIMENTS SLIGHTLY CONSOLIDATED LACUSTRINE SILT AND CLAY WITH SCATTERED LENSES OF SAND AND GRAVEL
mv	META-VOLCANICS BLOCKY JOINTED, SLIGHTLY METAMORPHOSED VOLCANIC ROCKS

SYMBOLS

GEOLOGIC CONTACT

FAULT

GEOLOGIC SECTION



SECTION A-A'-A"

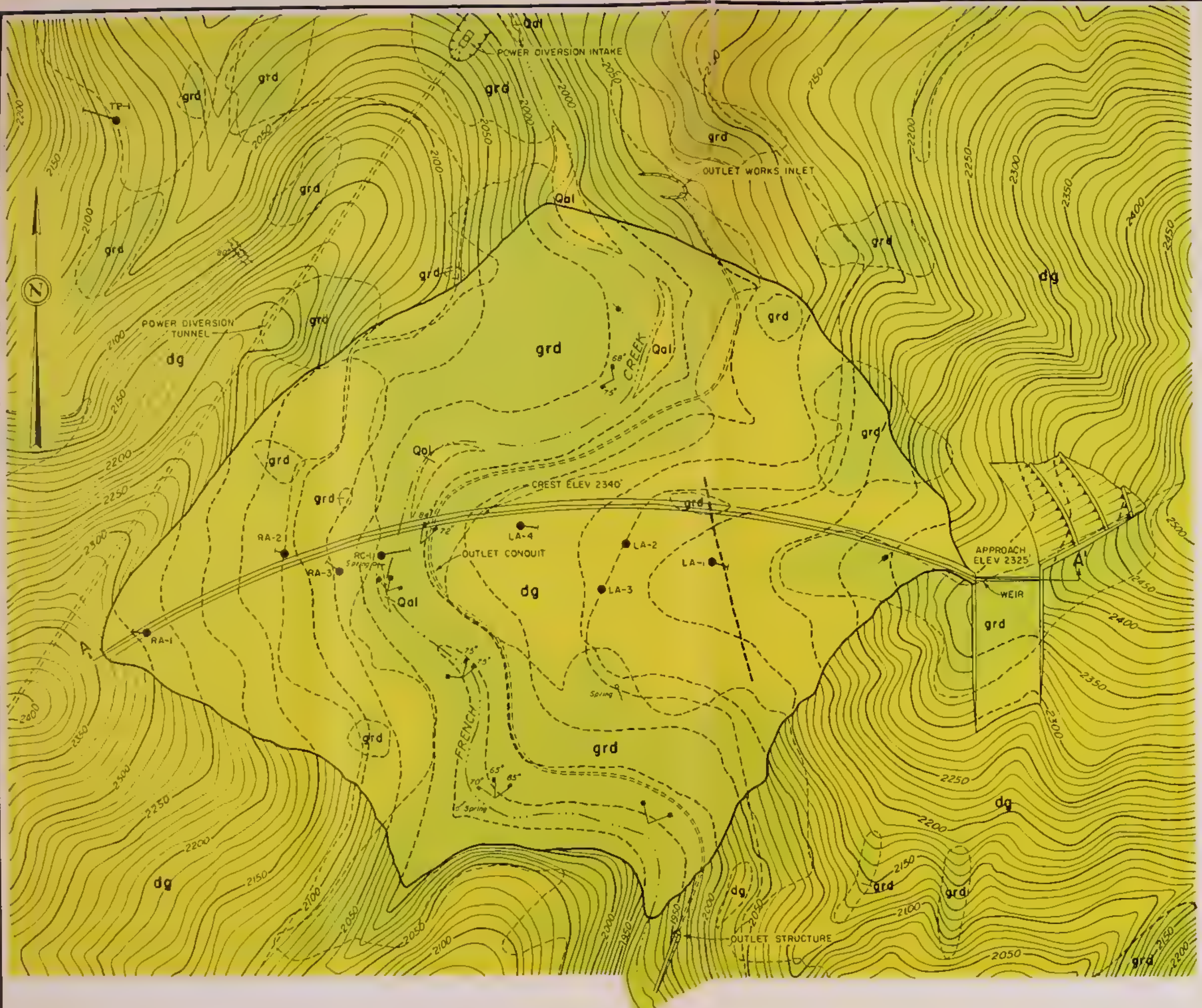
STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

DIVISION OF RESOURCES PLANNING

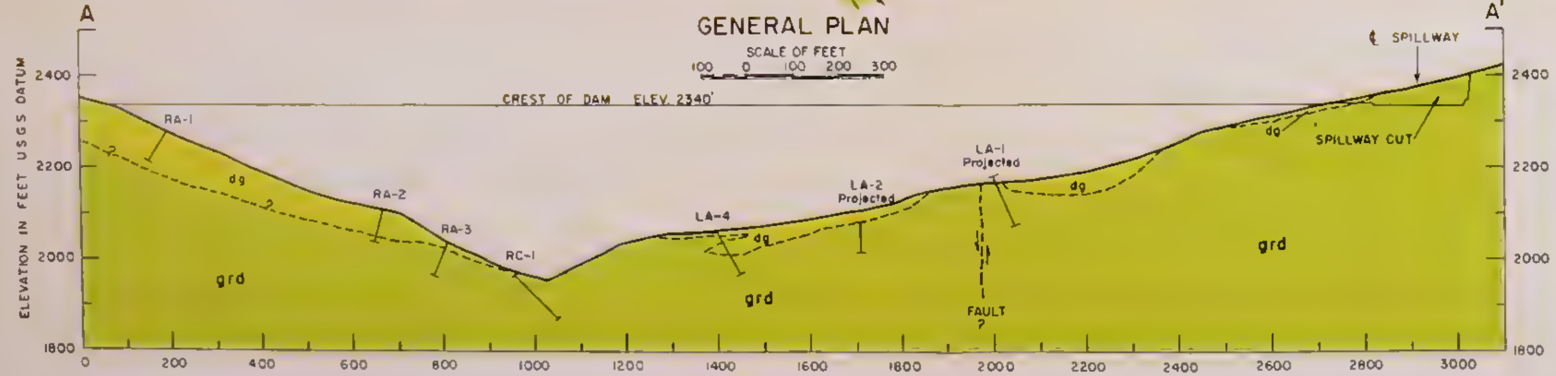
UPPER FEATHER RIVER BASIN INVESTIGATION

CLIO DAM ON MIDDLE FORK FEATHER RIVER

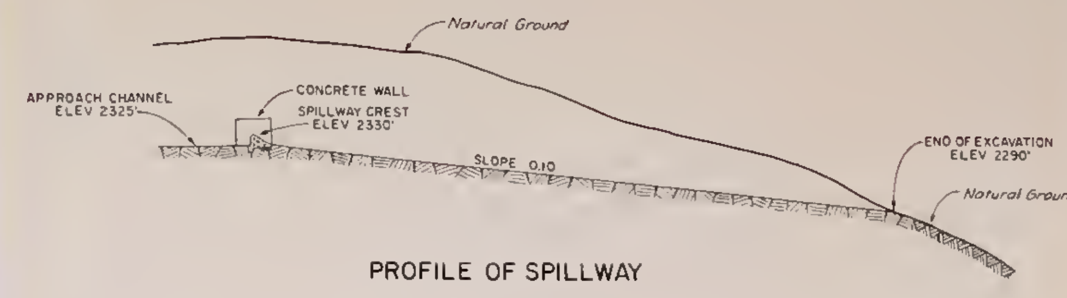


GENERAL PLAN

SCALE OF FEET

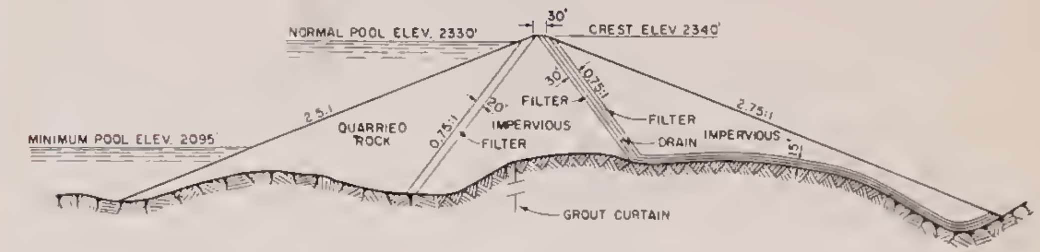


SECTION A-A'



PROFILE OF SPILLWAY

SCALE OF FEET



SECTION OF DAM

SCALE OF FEET

LEGEND

Qal ALLUVIUM
STREAM DEPOSITED GRAVEL, SAND AND SILT. MAXIMUM DEPTH ABOUT 5 FEET

dg DECOMPOSED GRANODIORITE
LIGHT GRAY, SOFT, CRUMBLY, INCOMPETENT MATERIAL

grd GRANODIORITE
GRANITIC ROCK, VERY HARD, COMPETENT

SYMBOLS

- GEOLOGIC CONTACT
- FAULT
- SHEAR
- JOINT, SINGLE
- JOINT, MULTIPLE SYSTEM
- SPRING
- LA-1 FOUNDATION DRILL HOLE, VERTICAL
- RA-2 FOUNDATION DRILL HOLE, INCLINED
- LA-2 FOUNDATION DRILL HOLE (SECTION)
- A A' GEOLOGIC SECTION

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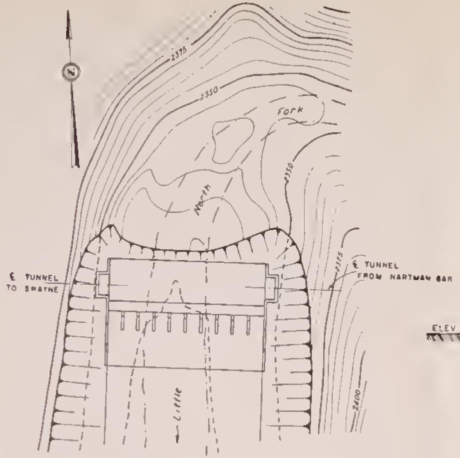
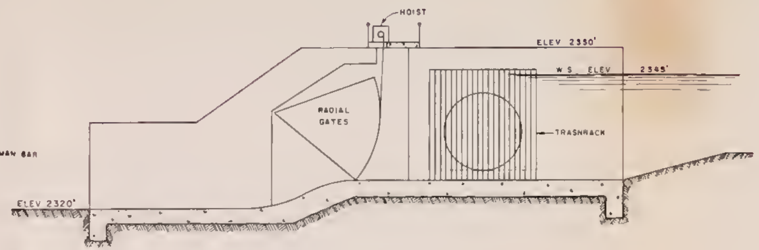
UPPER FEATHER RIVER BASIN INVESTIGATION

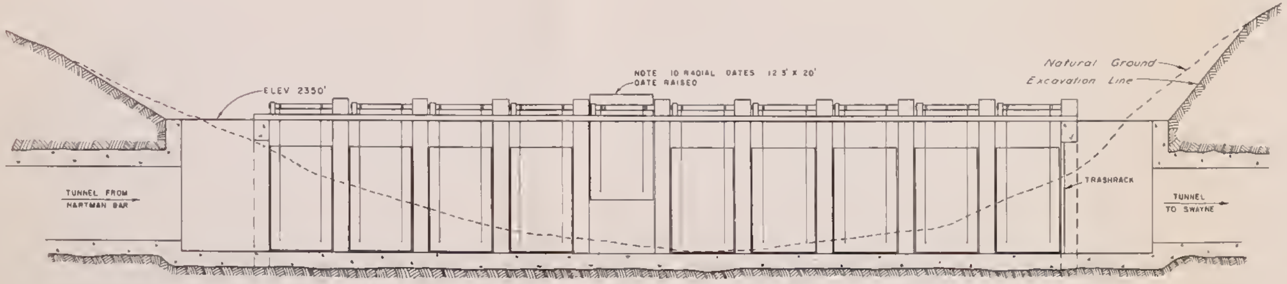
SWAYNE DAM ON FRENCH CREEK



GENERAL PLAN
SCALE OF FEET
50 0 50

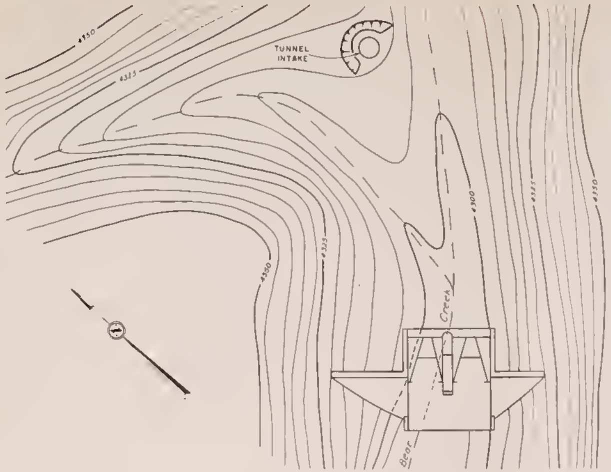


PROFILE OF DIVERSION DAM
THROUGH GATE
SCALE OF FEET
10 0 10

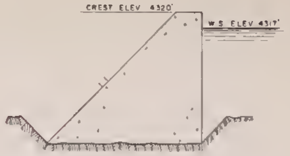


PROFILE OF DIVERSION DAM
THROUGH ℄ OF TUNNELS
LOOKING DOWNSTREAM
SCALE OF FEET
10 0 10

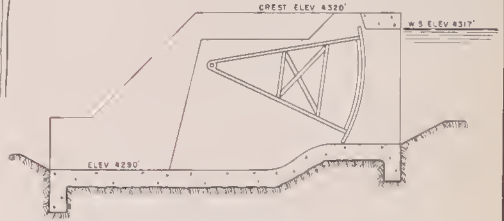
SPOON DIVERSION DAM



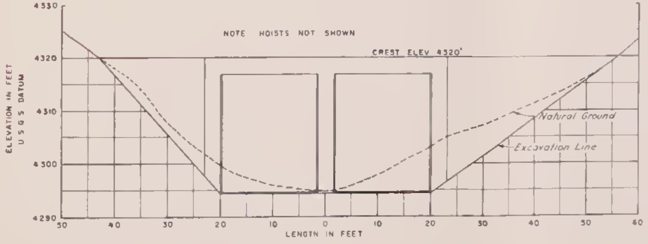
GENERAL PLAN
SCALE OF FEET
25 0 25



NON OVER-POUR SECTION
OF
DIVERSION DAM
SCALE OF FEET
10 0 10



SECTION OF DIVERSION DAM
THROUGH GATE
SCALE OF FEET
10 0 10



PROFILE OF DIVERSION DAM
LOOKING DOWNSTREAM

RED RIDGE DIVERSION DAM

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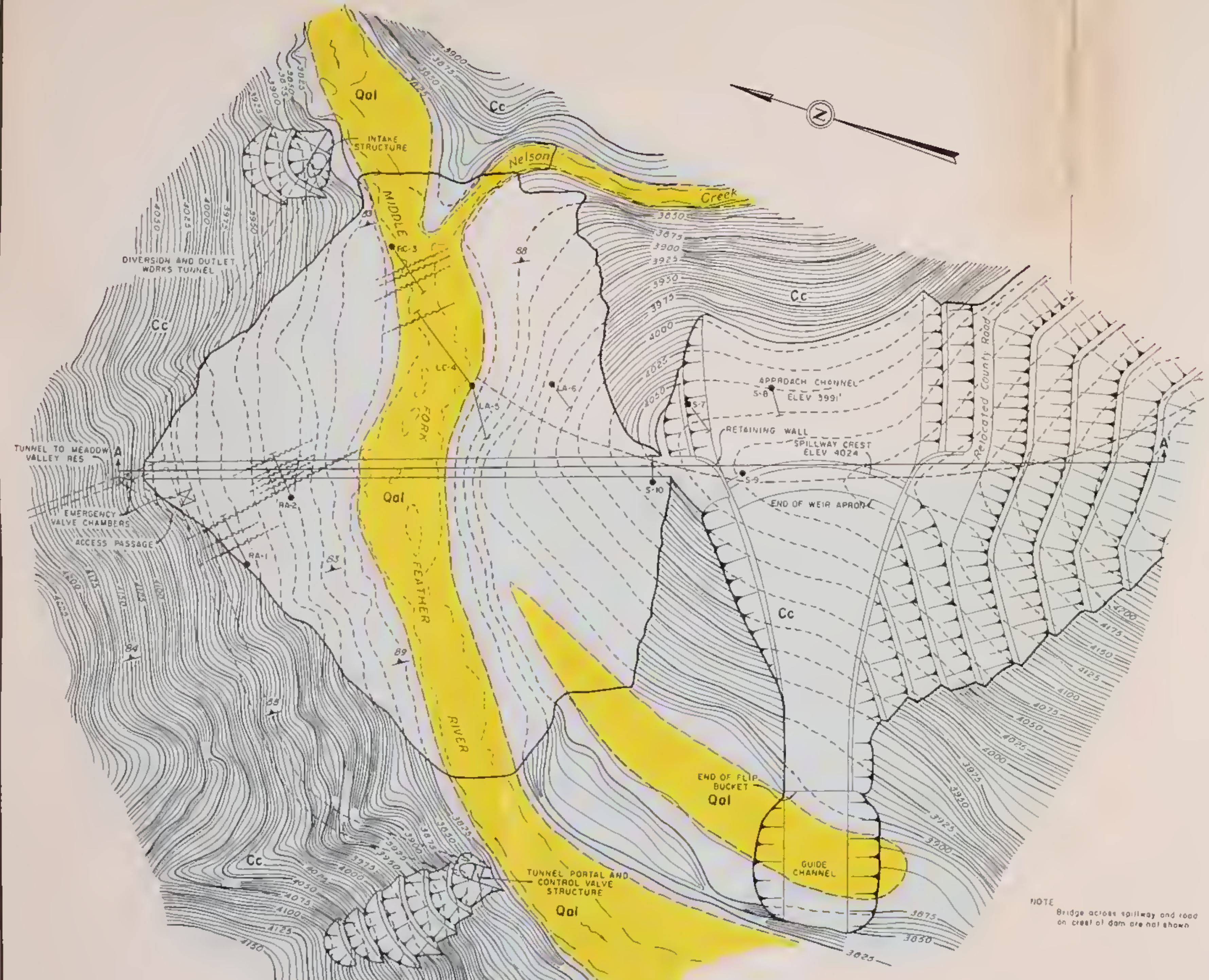
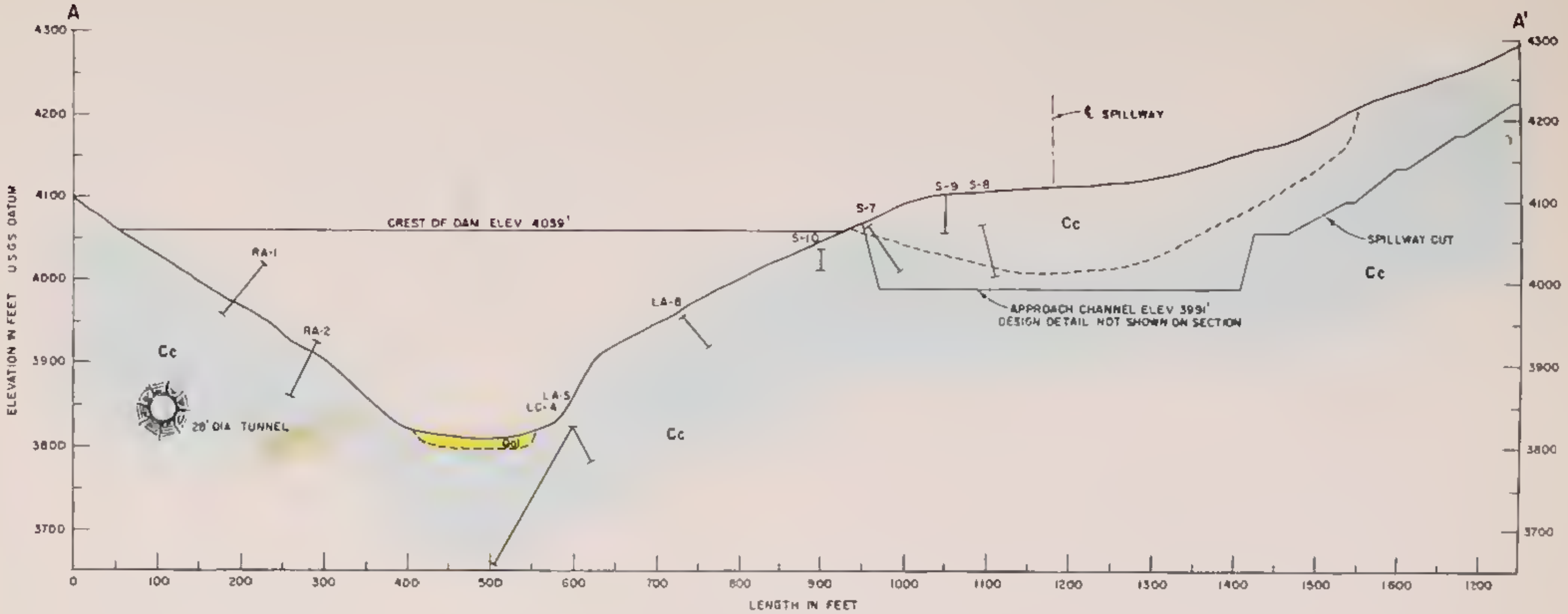
UPPER FEATHER RIVER BASIN INVESTIGATION

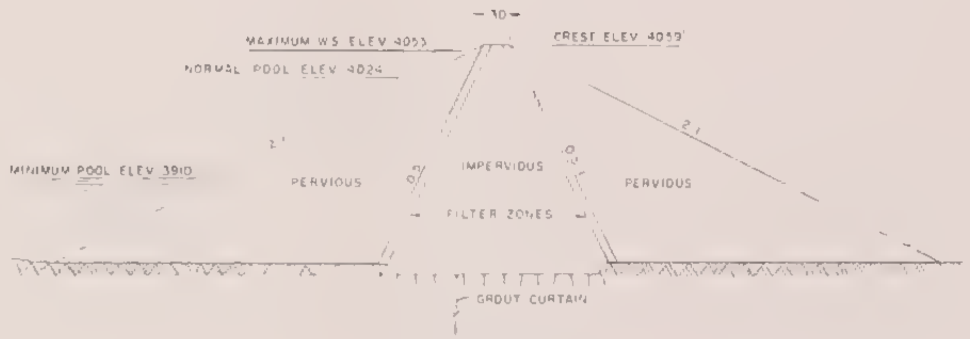
SPOON DIVERSION DAM ON LITTLE NORTH FORK AND RED RIDGE DIVERSION DAM ON BEAR CREEK



GENERAL PLAN
SCALE OF FEET



SECTION A-A'



SECTION OF DAM
SCALE OF FEET

LEGEND

Qal	**ALLUVIUM** GRAVEL AND SAND
Cc	**CALAVERAS FORMATION** THINLY BEDDED, VERTICALLY DIPPING SLATE, PHYLLITE, QUARTZITE, AND LIMESTONE
	SLUMPED, DEEPLY WEATHERED AND BROKEN ZONE

SYMBOLS

- GEOLOGIC CONTACT
- SHEAR, DETERMINED FROM DRILL HOLE DATA
- LA 6 FOUNDATION DRILL HOLE, VERTICAL AND INCLINED
- 88° STRIKE AND DIP OF FOLIATION
- RA-1 FOUNDATION DRILL HOLE (SECTION)
- A A GEOLOGIC SECTION

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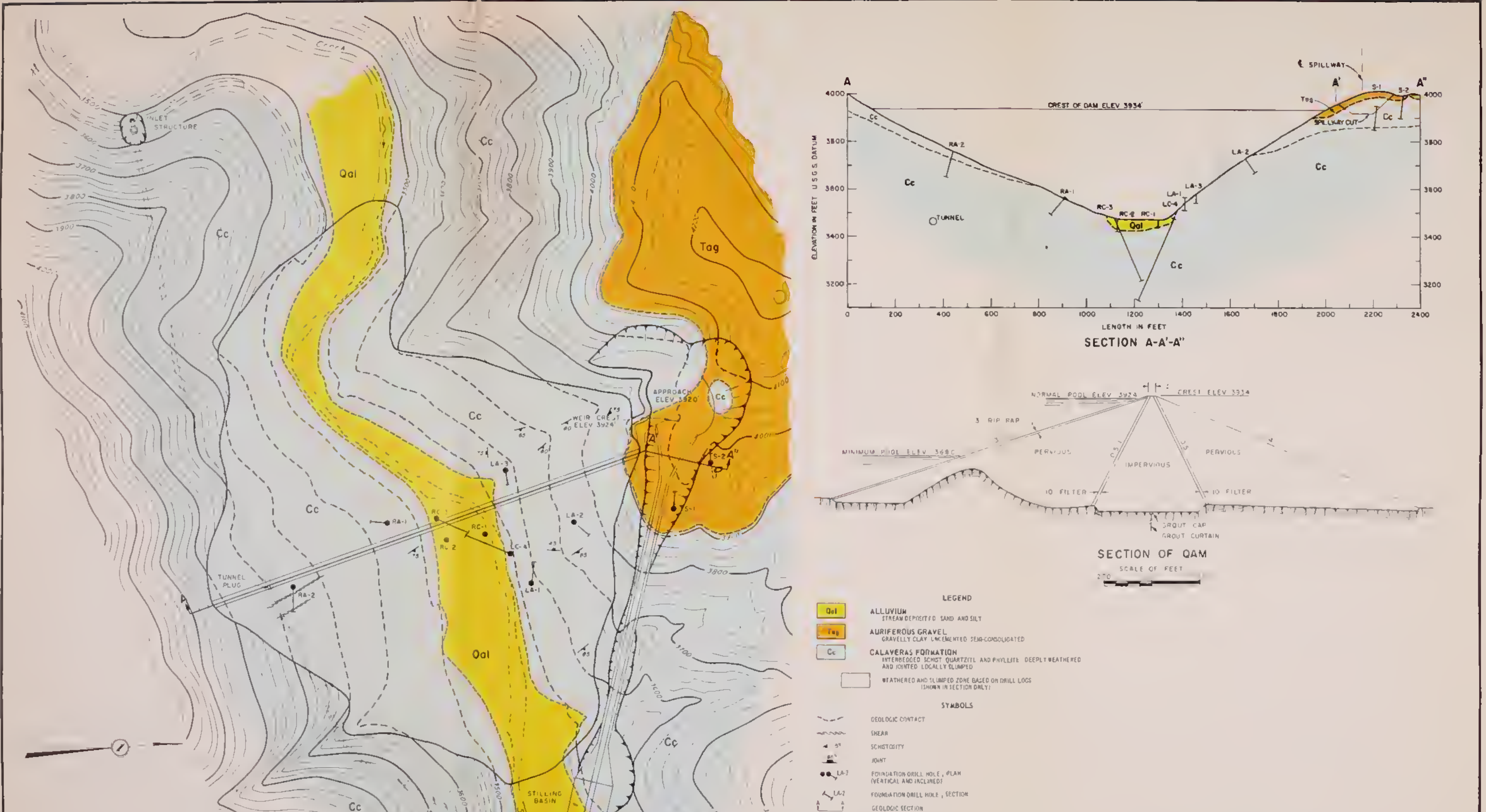
UPPER FEATHER RIVER BASIN INVESTIGATION

TURNTABLE DAM ON MIDDLE FORK FEATHER RIVER



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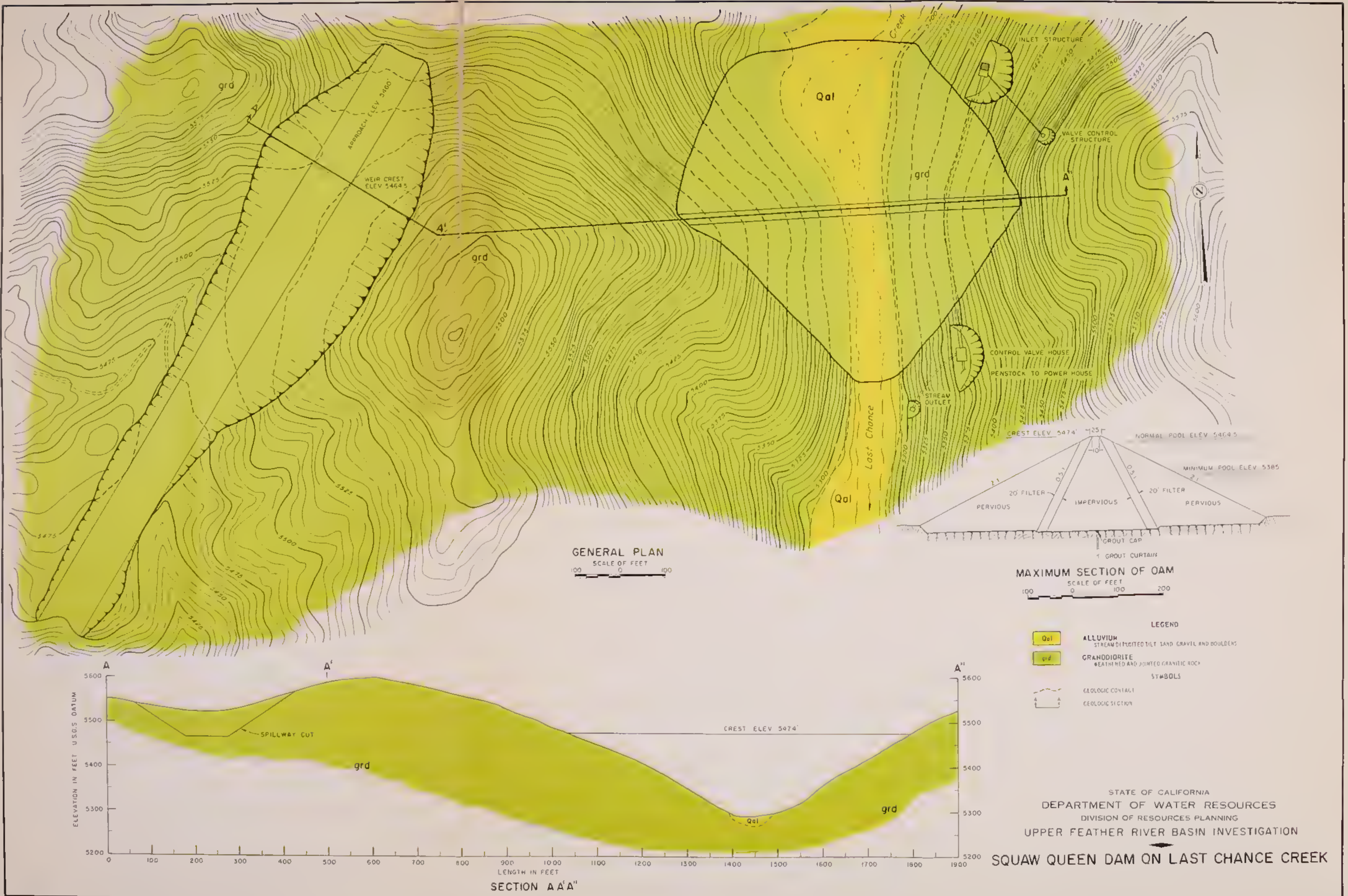
UPPER FEATHER RIVER BASIN INVESTIGATION

MEADOW VALLEY DAM ON SPANISH CREEK


GENERAL PLAN
SCALE OF FEET
INLET STRUCTURE
VALVE CONTROL STRUCTURE
APPROACH ELEV 5460
WEIR CREST ELEV 5464.5
CONTROL VALVE HOUSE
PENSTOCK TO POWER HOUSE
STREAM OUTLET
Last Chance
Creek
Qal
grd
A
A'
A''
MAXIMUM SECTION OF DAM
CREST ELEV 5474'
NORMAL POOL ELEV 5469.5
MINIMUM POOL ELEV 5385
20' FILTER
PERVIOUS
IMPERVIOUS
GROUT CAP
GROUT CURTAIN
LEGEND
ALLUVIUM
GRANODIORITE
SYMBOLS
GEOLOGIC CONTACT
GEOLOGIC SECTION
SPILLWAY CUT
CREST ELEV 5474'
ELEVATION IN FEET U.S.G.S. DATUM
LENGTH IN FEET
SECTION A A' A''
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
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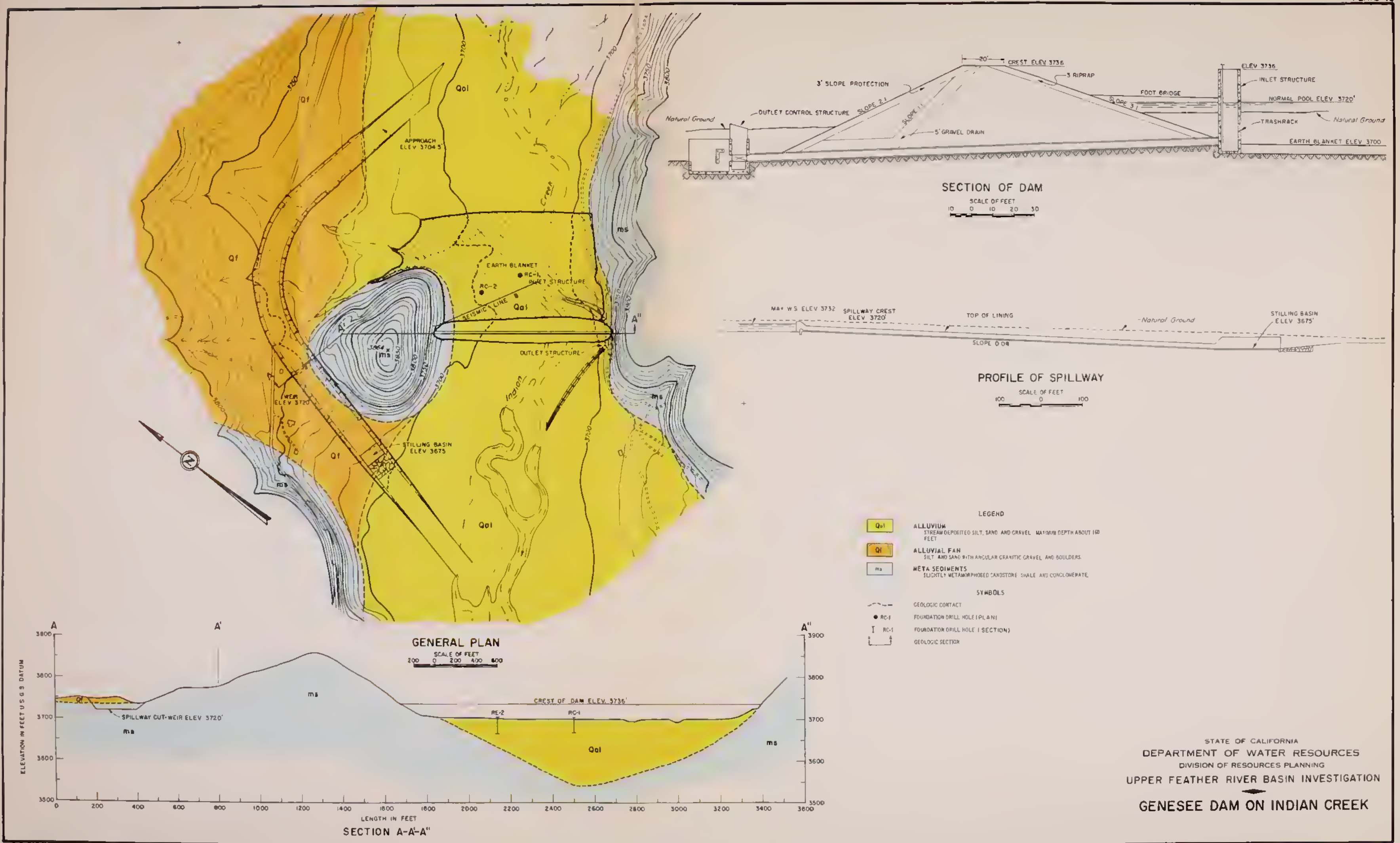
UPPER FEATHER RIVER BASIN INVESTIGATION
SQUAW QUEEN DAM ON LAST CHANCE CREEK


SECTION OF DAM
SCALE OF FEET
20'
CREST ELEV 3736
3' RIPRAP
3' SLOPE PROTECTION
ELEV 3736
INLET STRUCTURE
FOOT BRIDGE
NORMAL POOL ELEV 3720'
Natural Ground
OUTLET CONTROL STRUCTURE
SLOPE 2:1
SLOPE 3:1
TRASHRACK
5' GRAVEL DRAIN
EARTH BLANKET ELEV 3700
PROFILE OF SPILLWAY
SCALE OF FEET
MAX W S ELEV 3732
SPILLWAY CREST ELEV 3720'
TOP OF LINING
STILLING BASIN ELEV 3675'
SLOPE 0.04
GENERAL PLAN
SCALE OF FEET
APPROACH ELEV 3704.5'
EARTH BLANKET
RC-1
RC-2
INLET STRUCTURE
SEISMIC LINE
OUTLET STRUCTURE
WEIR ELEV 3720
STILLING BASIN ELEV 3675
Indian Creek
Qal
Qf
ms
SECTION A-A'-A''
CREST OF DAM ELEV 3736'
SPILLWAY CUT-WEIR ELEV 3720'
ELEVATION IN FEET U S G S DATUM
LENGTH IN FEET
LEGEND
ALLUVIUM
STREAM DEPOSITED SILT, SAND AND GRAVEL. MAXIMUM DEPTH ABOUT 160 FEET
ALLUVIAL FAN
SILT AND SAND WITH ANGULAR GRANITIC GRAVEL AND BOULDERS
META SEDIMENTS
SLIGHTLY METAMORPHOSED SANDSTONE SHALE AND CONGLOMERATE
SYMBOLS
GEOLOGIC CONTACT
FOUNDATION DRILL HOLE (PLAN)
FOUNDATION DRILL HOLE (SECTION)
GEOLOGIC SECTION
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
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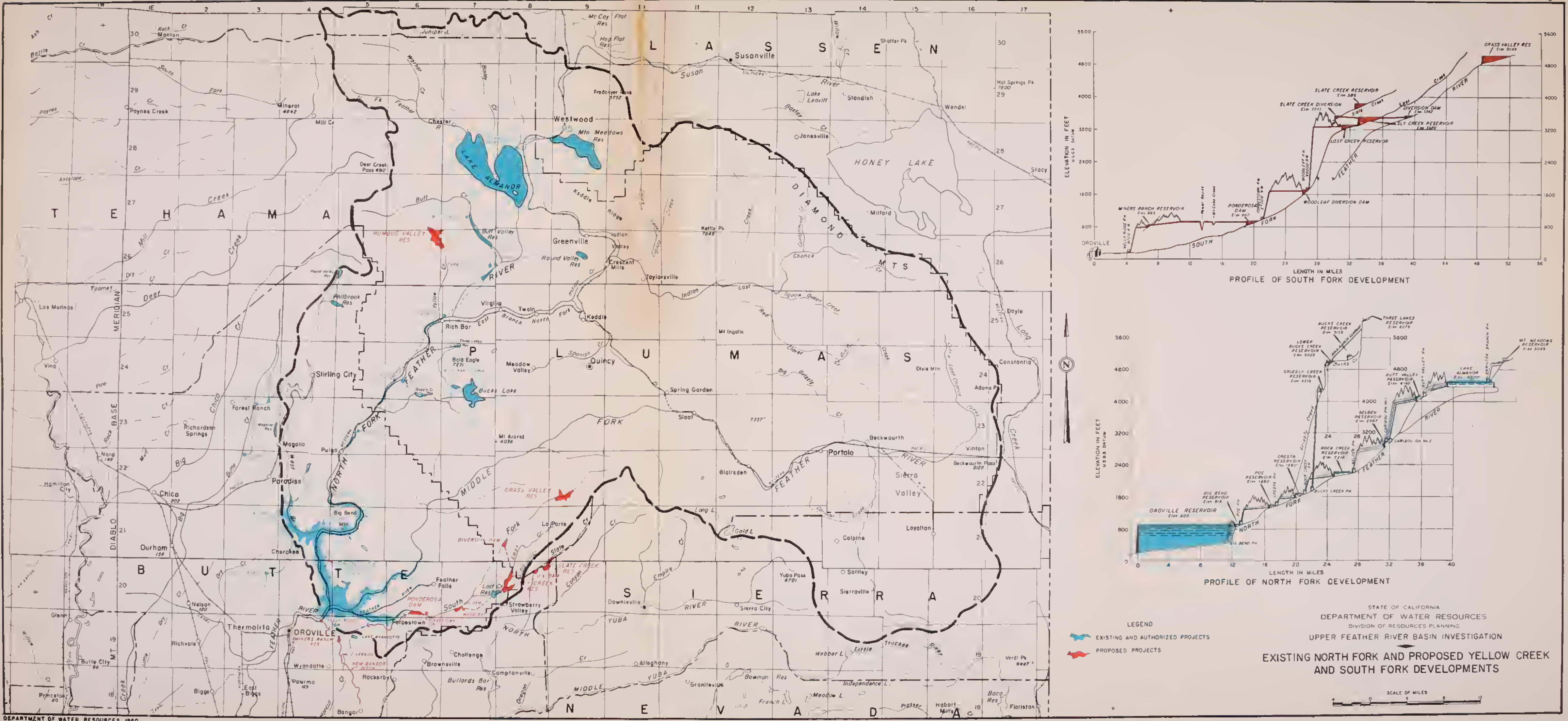
UPPER FEATHER RIVER BASIN INVESTIGATION
GENESEE DAM ON INDIAN CREEK



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UPPER FEATHER RIVER BASIN INVESTIGATION

EXISTING NORTH FORK AND PROPOSED YELLOW CREEK AND SOUTH FORK DEVELOPMENTS